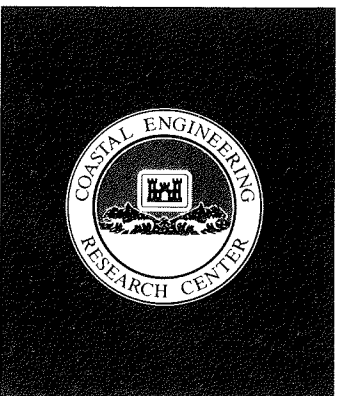
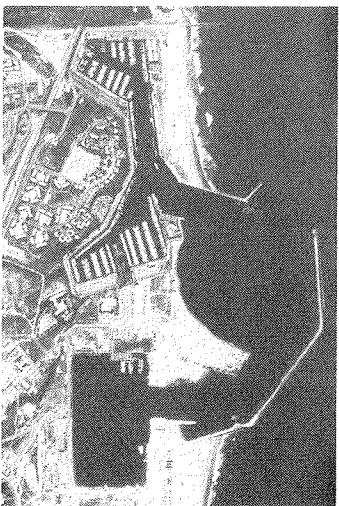
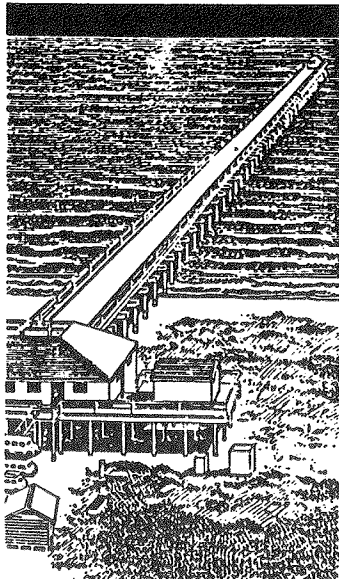




**US Army Corps
of Engineers**



TECHNICAL REPORT CERC-92-14

OCEANSIDE HARBOR, CALIFORNIA DESIGN FOR HARBOR IMPROVEMENTS

Coastal Model Investigation

by

Robert R. Bottin, Jr.

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY

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September 1992

Final Report

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13. ABSTRACT (Maximum 200 words) A 1:75 scale, three-dimensional hydraulic model was used to investigate the design of a proposed harbor structure and channel modifications at Oceanside Harbor, California, with respect to wave and shoaling conditions in the harbor entrance and wave conditions in the inner harbor. The model reproduced approximately 9,000 ft of the California shoreline and included portions of the existing harbor and offshore bathymetry in the Pacific Ocean to a depth of 36 ft mean lower low water (mllw). Improvement plans consisted of a seaward extension of the existing north breakwater, the installation of a spur on the south jetty, and modifications to the entrance channel. An 80-ft-long unidirectional, spectral wave generator, an automated data acquisition system, and crushed coal tracer material were utilized in model operation. It was concluded from the test results that: (Continued)				
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19. (Concluded).

- a. For the existing harbor configuration, wave heights in the inner harbor were more severe during periods when the shoal in the entrance channel was not present. With the shoaled entrance, waves broke and expended some of their energy, while with the dredged entrance (authorized depths), more wave energy propagated into the harbor.
- b. The originally proposed improvement plan (Plan 1, 180-ft-long jetty spur (el +14 ft) and 300-ft-long breakwater extension (el +18 ft)) will result in wave conditions in the inner harbor in excess of the established criteria (0.2, 0.4, and 0.6 ft for weekly, annual, and 20-yr wave conditions, respectively).
- c. Of the improvement plans tested with the jetty spur on its original alignment (Plans 1-13), only the 230-ft-long jetty spur and the 450-ft-long breakwater extension of Plan 7 met the established wave height criteria.
- d. Of the improvement plans tested with the reoriented jetty spur (Plans 14-22), only the 280-ft-long jetty spur and the 300-ft-long breakwater extension of Plan 22 met the established wave height criteria.
- e. Of all the improvement plans tested from 235 deg, and considering wave protection afforded versus volume of construction materials, the 180-ft-long jetty spur and the 250-ft-long breakwater extension of Plan 17 were considered optimal. The wave height criteria will be exceeded by 0.1 ft at only one gage location in the inner harbor for weekly and annual wave conditions.
- f. The Plan 17 harbor configuration will result in wave heights in the inner harbor that are 60 percent less, on the average, than those obtained for existing conditions (with authorized channel depths) for test waves from the more predominant 235-deg direction.
- g. Wave heights in the outer entrance will be reduced as a result of the installation of Plan 17 for test waves from the more predominant 235-deg direction.
- h. Considering test waves from the 250- and 210-deg directions, the wave height criteria in the inner harbor will be exceeded by only 0.1 ft at one gage location for weekly, annual, and/or 20-yr wave conditions when Plan 17 is in place.
- i. The installation of the Plan 17 structures should not impact sediment patterns on a regional basis. Sediment will continue to move into the expanded entrance, but it will deposit more seaward in the entrance and will not penetrate as deeply into the entrance channel.
- j. Model results indicate that installation of Plan 17 will not have any impact on long-period wave conditions in the inner harbor basins.

PREFACE

A request for a model investigation of wave and shoaling conditions at Oceanside Harbor, California, was initiated by the US Army Engineer District, Los Angeles (SPL), in a letter to the US Army Engineer Division, South Pacific (SPD). Authorization for the US Army Engineer Waterways Experiment Station (WES) to perform the study was subsequently granted by Headquarters, US Army Corps of Engineers. Funds for model testing were authorized by SPL on 11 December 1989, 10 January 1990, 13 August 1990, and 1 November 1991.

Model tests were conducted at WES intermittently during the period October 1990 through February 1992 by personnel of the Wave Processes Branch (WPB) of the Wave Dynamics Division (WDD), Coastal Engineering Research Center (CERC) under the direction of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director of CERC, respectively; and under the direct guidance of Messrs. C. E. Chatham, Jr., Chief of WDD; and Dennis G. Markle, Chief of WPB. Tests were conducted by Messrs. Marvin G. Mize, Hugh F. Acuff, Larry R. Tolliver, and William G. Henderson, under the supervision of Mr. Robert R. Bottin, Jr., Project Manager. This report was prepared by Mr. Bottin, typed by Ms. Debbie S. Fulcher, WPB, and edited by Ms. Janean Shirley, Information Technology Laboratory, WES.

Prior to the model investigation, Messrs. Bottin and Markle met with representatives of SPL and visited Oceanside Harbor to inspect the prototype site and attend a general design conference. During the course of the investigation, liaison was maintained by means of conferences, telephone communications, and monthly progress reports. Mr. Chuck Mesa, SPL, visited WES and was present during some model testing. Other visitors to WES, who observed model operation and/or participated in conferences, during the course of the study were:

Mr. George Domurat	US Army Engineer Division, South Pacific
Mr. Brian Moore	US Army Engineer District, Los Angeles
Mr. Robert Koplin	US Army Engineer District, Los Angeles
Mr. Robert Hall	US Army Engineer District, Los Angeles
Mr. Art Shak	US Army Engineer District, Los Angeles
Mr. Michael Piszker	US Army Engineer District, Los Angeles
Ms. Melba Bishop	Vice Mayor, City of Oceanside
Mr. Don Rodee	Councilman, City of Oceanside
Mr. Jim Manues	Chief Executive Officer, Oceanside Harbor District
Mr. Dan Hadley	Interim Chief Executive Officer, City of Oceanside
Dr. Kimo Walker	Consultant, Moffatt & Nichols
Mr. Bob Sepe	California Department of Boating and Waterways
Mr. Jerry Wolf	Harbor Maintenance Foreman, Oceanside Harbor

Dr. Scott Jenkins Surfrider Foundation

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

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CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI
(metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
degrees (angle)	0.01745329	radians
feet	0.3048	metres
miles (US statute)	1.609347	kilometres
square feet	0.09290304	square metres
square miles (US statute)	2.589998	square kilometres

OCEANSIDE HARBOR, CALIFORNIA, DESIGN
FOR HARBOR IMPROVEMENTS
Coastal Model Investigation

PART I: INTRODUCTION

The Prototype

1. Oceanside Harbor is located on the California coast approximately 80 miles* south of Los Angeles and 30 miles north of San Diego (Figure 1). The harbor complex includes the Del Mar Boat Basin (also known as Camp Pendleton Harbor) and the Oceanside Small-Craft Harbor. While the Del Mar Boat Basin is used entirely for military purposes, Oceanside Small-Craft Harbor is used primarily for recreation (approximately 95 percent recreation and 5 percent commercial craft). The two basins share a common entrance but have separate channels leading to their respective berthing areas.

2. The harbors are currently protected by a 4,350-ft-long north breakwater and 1,330-ft-long south jetty. The north breakwater and south jetty have crest elevations (el) of +21 ft** and +14 ft, respectively. The Federal channel commences approximately 400 ft seaward of the navigation opening between the heads of the north breakwater and south jetty and extends to the Del Mar Boat Basin and Oceanside Small-Craft Harbor basin entrances. The authorized channel depth is -20 ft, and the width of the approach channel is 750 ft. Responsibility for maintenance dredging is shared by the US Army Corps of Engineers and the US Navy. The north breakwater is maintained by the Navy. The harbor has undergone several modifications, repairs, improvements, etc. since initial construction began in 1942 (US Army Engineer District (USAED), Los Angeles 1989; Bottin 1988). An aerial photograph of the harbor is shown in Figure 2.

* A table of factors for converting Non-SI units of measurement to SI (metric) units is presented on page 4.

** All elevations (el) cited herein are in feet referred to mean lower low water (mllw).

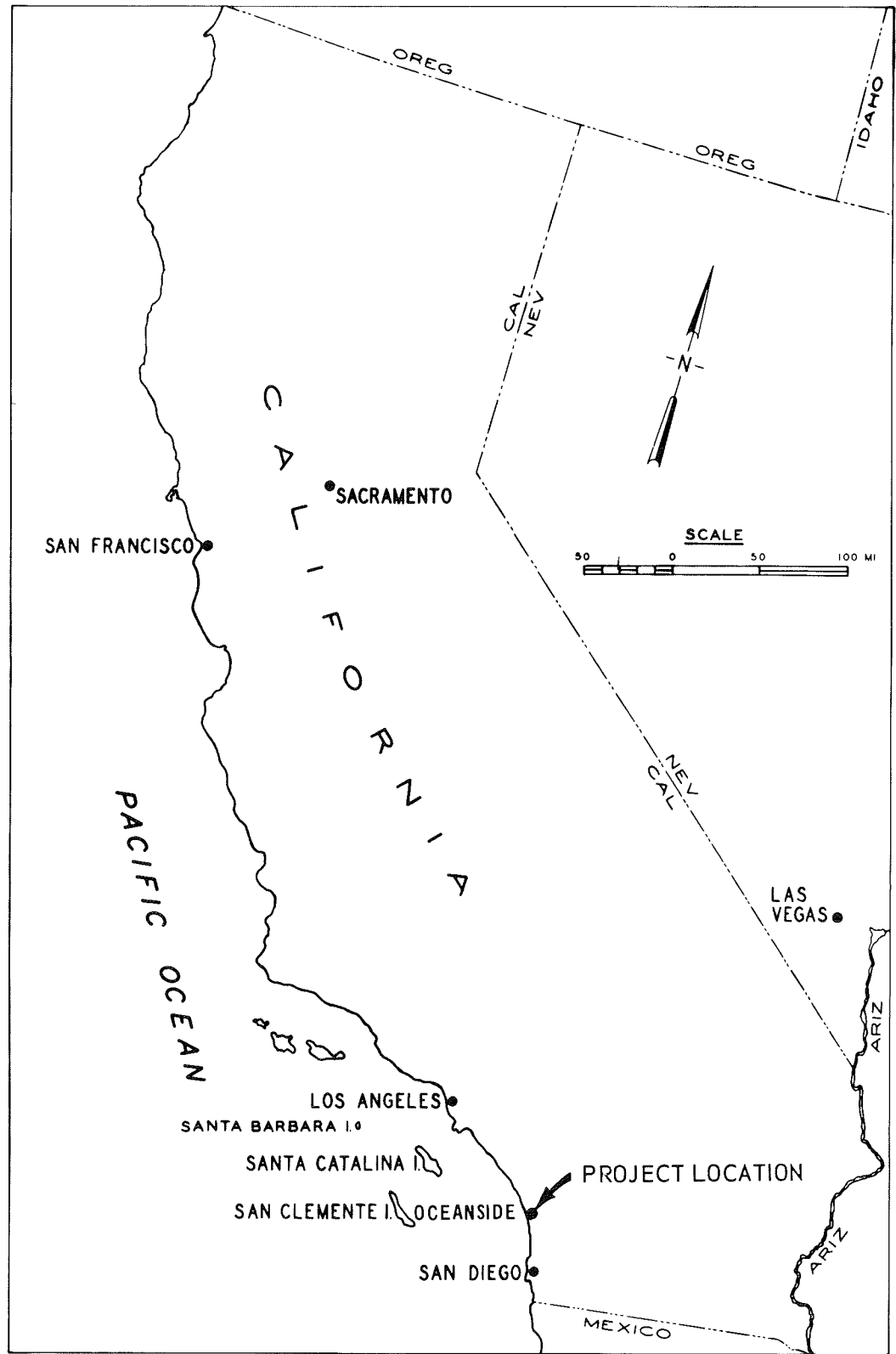


Figure 1. Project location

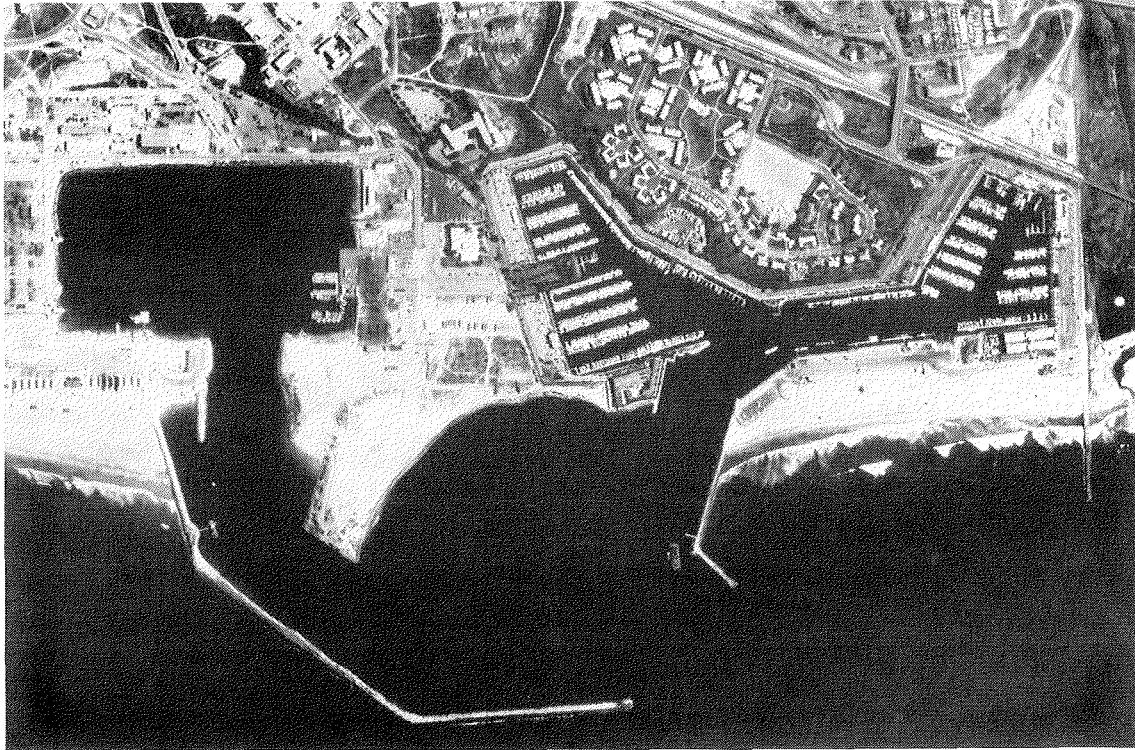


Figure 2. Aerial view of Oceanside Harbor

The Problem

3. Accumulation of sediment in the harbor entrance creates hazardous navigation conditions for both commercial and recreational craft, due to breaking waves and shallow depths. These breaking waves cause boats to broach, capsize, run aground, and/or collide with other boats and/or the jetty. Strong local wave-induced currents can also drive vessels toward the south jetty once they are in the entrance. Annual loss of income to harbor operations and vessel damages averages about \$140,000, and 11 persons have lost their lives attempting to navigate the entrance since 1963 (USAED, Los Angeles 1989).

4. Due to the configuration of the harbor, waves from critical directions can penetrate relatively uninterrupted through the main channel entrance and into the inner harbor berthing area of Oceanside Small-Craft Harbor. Excessive wave-related damages are experienced in the berthing areas. Estimated average annual storm damage to floats, piles, revetments, and commercial

and recreational vessels is estimated at approximately \$520,000 (USAED, Los Angeles 1989).

Purpose of Model Study

5. At the request of the USAED, Los Angeles (SPL), a physical coastal hydraulic model investigation was initiated by the US Army Engineer Waterways Experiment Station's (WES's) Coastal Engineering Research Center (CERC) to:

- a. Study wave and shoaling conditions for the existing harbor configuration.
- b. Determine if proposed improvements would provide the protection required to meet the selected wave height acceptance criteria in the entrance and berthing areas of the harbor.
- c. Develop remedial plans, if necessary, for the alleviation of undesirable conditions.
- d. Determine whether design modifications could be made to the proposed plans that would reduce construction costs without adversely affecting project performance.

Wave-Height Criteria

6. Completely reliable criteria have not yet been developed for ensuring satisfactory navigation conditions in small-craft harbors during attack by storm waves. For this study, however, SPL specified that for an improvement plan to be acceptable, maximum significant wave heights in the inner harbor basins were not to exceed 0.6 ft for waves with a 20-yr recurrence, 0.4 ft for waves with an annual occurrence, and 0.2 ft for waves with a weekly recurrence interval.

PART II: THE MODEL

Design of Model

7. The Oceanside Harbor model (Figure 3) was constructed to an undistorted linear scale of 1:75, model to prototype. Scale selection was based on the following factors:

- a. Depth of water required in the model to prevent excessive bottom friction.
- b. Absolute size of model waves.
- c. Available shelter dimensions and area required for model construction.
- d. Efficiency of model operation.
- e. Available wave-generating and wave-measuring equipment.
- f. Model construction costs.

A geometrically undistorted model was necessary to ensure accurate reproduction of wave and current patterns. Following selection of the linear scale, the model was designed and operated in accordance with Froude's model law (Stevens et al. 1942). The scale relations used for design and operation of the model were as follows:

<u>Characteristic</u>	<u>Dimension*</u>	<u>Model-Prototype Scale Relations</u>
Length	L	$L_r = 1:75$
Area	L^2	$A_r = L_r^2 = 1:5,625$
Volume	L^3	$V_r = L_r^3 = 1:421,875$
Time	T	$T_r = L_r^{1/2} = 1:8.66$
Velocity	L/T	$V_r = L_r^{1/2} = 1:8.66$

* Dimensions are in terms of length (L) and time (T).

8. The existing breakwaters and revetments at Oceanside Harbor, as well as proposed improvements, were rubble-mound structures. Experience and experimental research have shown that considerable wave energy passes through the interstices of this type of structure; thus, the transmission and absorption of wave energy became a matter of concern in design of the 1:75-scale model. In small-scale hydraulic models, rubble-mound structures reflect relatively more and absorb or dissipate relatively less wave energy than geometrically similar prototype structures (Le Méhauté 1965). Also, the transmission of

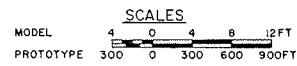


Figure 3. Model layout

wave energy through a rubble-mound structure is relatively less for the small-scale model than for the prototype. Consequently, some adjustment in small-scale model rubble-mound structures is needed to ensure satisfactory reproduction of wave-reflection and wave-transmission characteristics. In past investigations (Dai and Jackson 1966, Brasfield and Ball 1967) at WES, this adjustment was made by determining the wave-energy transmission characteristics of the proposed structure in a two-dimensional model using a scale large enough to ensure negligible scale effects. A section then was developed for the small-scale, three-dimensional model that would provide essentially the same relative transmission of wave energy. Therefore, from previous findings for structures and wave conditions similar to those at Oceanside Harbor, it was determined that a close approximation of the correct wave-energy transmission characteristics could be obtained by increasing the size of the rock used in the 1:75-scale model to approximately one-and-one-half times that required for geometric similarity. Accordingly, in constructing the rubble-mound structures in the Oceanside Harbor model, the rock sizes were computed linearly by scale, then multiplied by 1.5 to determine the actual sizes to be used in the model.

The Model and Appurtenances

9. The model reproduced about 9,000 ft of the California shoreline and included the Oceanside Outer Harbor, as well as the Oceanside Small-Craft Harbor, and bathymetry in the Pacific Ocean to an offshore depth of -36 ft with a sloping transition to the wave generator pit el of -75 ft. The total area reproduced in the model was approximately 15,650 sq ft, representing about 3.2 sq miles in the prototype. A general view of the model is shown in Figure 4. Vertical control for model construction was based on mllw. Horizontal control was referenced to a local prototype grid system.

10. Model waves were generated by an 80-ft-long, unidirectional spectral, electrohydraulic wave generator with a trapezoidal-shaped, vertical-motion plunger. The vertical motion of the plunger was controlled by a computer-generated command signal, and the movement of the plunger caused a displacement of water, which generated the required test waves. The wave generator was mounted on retractable casters, which enabled it to be positioned to generate waves from required directions.

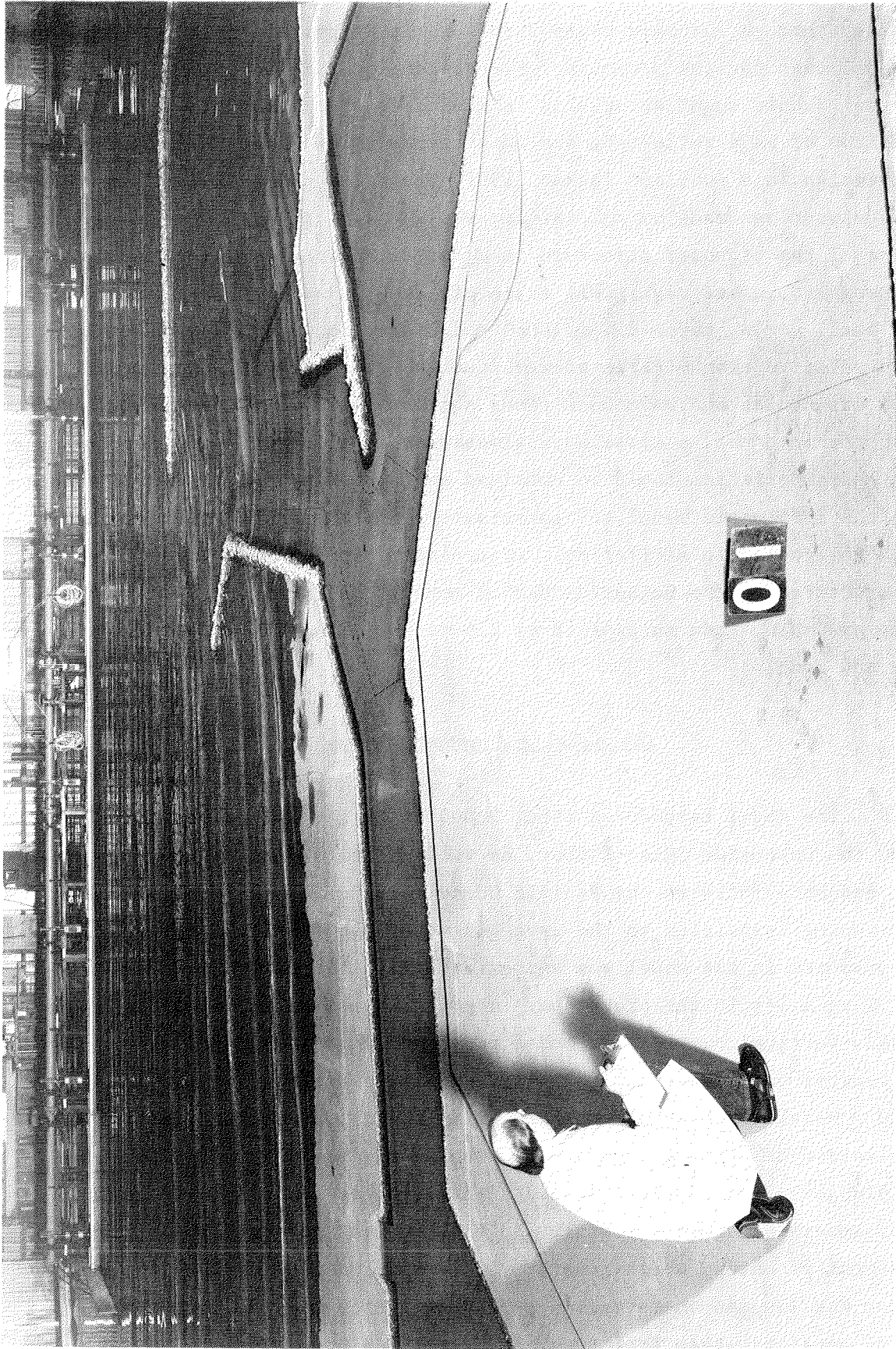


Figure 4. General view of model

11. An Automated Data Acquisition and Control System, designed and constructed at WES (Figure 5), was used to generate and transmit control signals, monitor wave generator feedback, and secure and analyze wave data at selected locations in the model. Through the use of a microvax computer, the electrical output of parallel-wire, resistance-type wave gages, which varied with the change in water-surface elevation with respect to time, were recorded on magnetic disks. These data were then analyzed to obtain the parametric wave data.

12. A 2-ft (horizontal) solid layer of fiber wave absorber was placed around the inside perimeter of the model to dampen wave energy that might

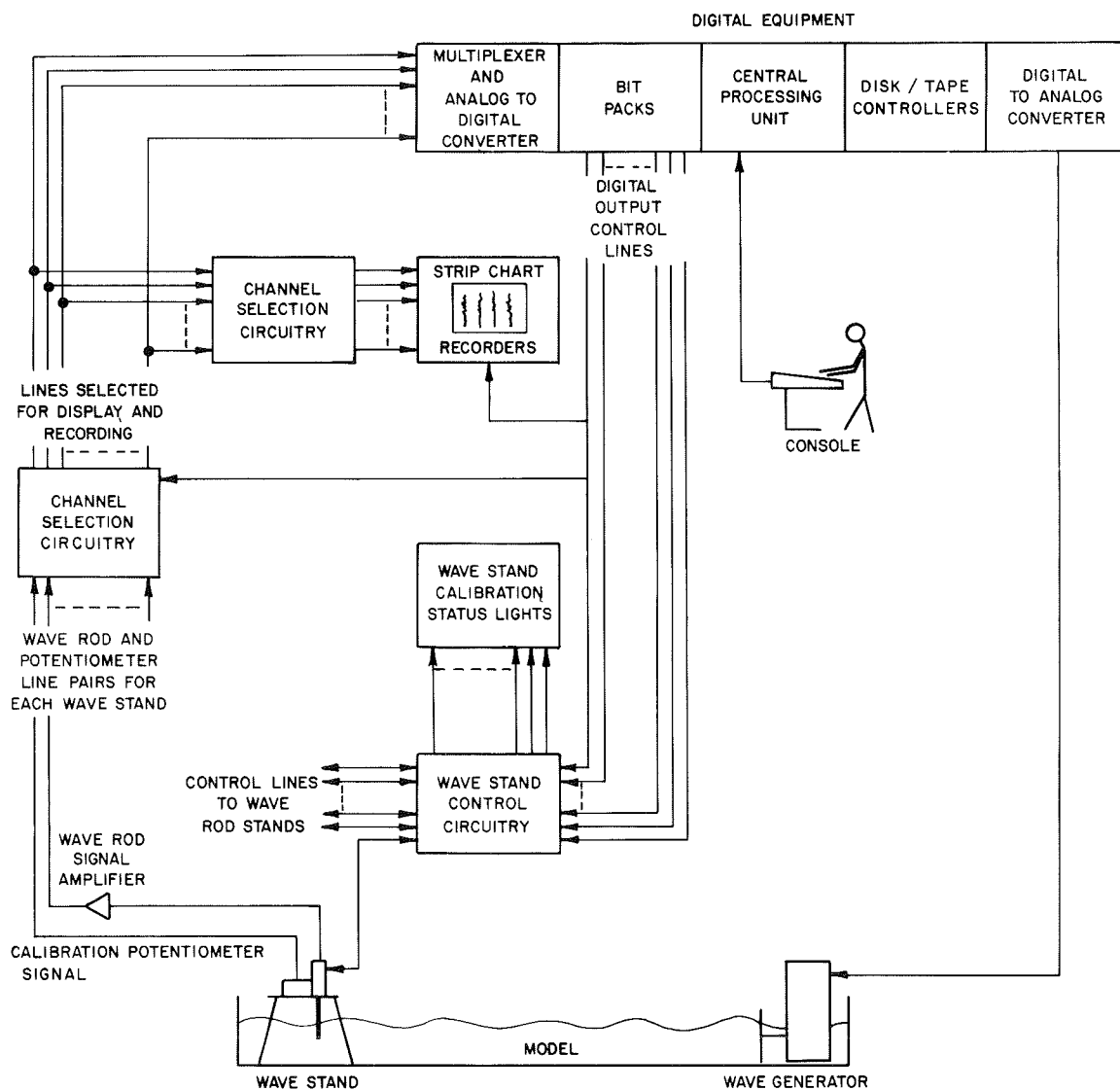


Figure 5. Automated Data Acquisition and Control System

otherwise be reflected from the model walls. In addition, guide vanes were placed along the wave generator sides in the flat pit area to ensure proper formation of the wave train incident to the model contours.

Selection of Tracer Material

13. A fixed-bed model, molded in cement mortar, was constructed and a tracer material selected to qualitatively determine the movement and deposition of sediment in the vicinity of the harbor. The tracer was chosen in accordance with the scaling relations of Noda (1972), which indicate a relation or model law among the four basic scale ratios; i.e., the horizontal scale, λ ; the vertical scale, μ ; the sediment size ratio, n_D ; and the relative specific weight ratio, n_γ . These relations were determined experimentally using a wide range of wave conditions and bottom materials and are valid mainly for the breaker zone.

14. Noda's scaling relations indicate that movable-bed models with scales in the vicinity of 1:75 (model to prototype) should be distorted (i.e., they should have different horizontal and vertical scales). Since the fixed-bed model of Oceanside Harbor was undistorted to allow accurate reproduction of short-period wave and current patterns, the following procedure was used to select a tracer material. Using the prototype sand characteristics (median diameter, $D_{50} = 0.20$ mm, specific gravity = 2.67) and assuming the horizontal scale to be in similitude (i.e. 1:75), the median diameter for a given specific gravity of tracer material and the vertical scale were computed. The vertical scale was then assumed to be in similitude and the tracer median diameter and horizontal scale were computed. This resulted in a range of tracer sizes for given specific gravities that could be used. Although several types of movable-bed tracer materials were available at WES, previous investigations (Giles and Chatham 1974, Bottin and Chatham 1975) indicated that crushed coal tracer more nearly represented the movement of prototype sand. Therefore, quantities of crushed coal (specific gravity = 1.30; median diameter, $D_{50} = 0.51$ mm) were selected for use as a tracer material throughout the model investigation.

PART III: TEST CONDITIONS AND PROCEDURES

Selection of Test Conditions

Still-water level

15. Still-water levels (swl's) for harbor wave action models are selected so that the various wave-induced phenomena that are dependent on water depths are accurately reproduced in the model. These phenomena include refraction of waves in the project area, overtopping of harbor structures by waves, reflection of wave energy from various structures, and transmission of wave energy through porous structures.

16. In most cases, it is desirable to select a model swl that closely approximates the higher water stages that normally occur in the prototype for the following reasons:

- a. The maximum amount of wave energy reaching a coastal area normally occurs during the higher water phase of the local tidal cycle.
- b. Most storms moving onshore are characteristically accompanied by a higher water level due to wind tide and shoreward mass transport.
- c. The selection of a high swl helps minimize model scale effects due to viscous bottom friction.
- d. When a high swl is selected, a model investigation tends to yield more conservative results.

17. Oceanside Harbor experiences two high and two low tides daily, typical of the Pacific Coast of North America. These tides are of diurnal inequality. The range between mean lower low water and mean higher high water is 5.4 ft. The highest tides of the year usually occur in the winter months. Extreme high water elevations at Oceanside Harbor are estimated at 7.1 ft and 7.7 ft for 5- and 100-yr recurrence intervals, respectively (USAED, Los Angeles 1989). Elevations of 0.0 ft and +5.4 ft (mean higher high water el) are considered to represent the average astronomical tide range, and were therefore selected by SPL for use during model testing.

Factors influencing selection of test wave characteristics

18. In planning the testing program for a model investigation of harbor wave-action problems, it is necessary to select heights, periods, and directions for the test waves that will allow a realistic test of proposed improvement plans and an accurate evaluation of the elements of the various

proposals. Surface-wind waves are generated primarily by the interactions between tangential stresses of wind flowing over water, resonance between the water surface and atmospheric turbulence, and interactions between individual wave components. The height and period of the maximum significant wave that can be generated by a given storm depend on the wind speed, the length of time that wind of a given speed continues to blow, and the distance over water that the wind blows (fetch). Selection of test wave conditions entails evaluation of such factors as:

- a. The fetch and decay distances (the latter being the distance over which waves travel after leaving the generating area) for various directions from which waves can approach the problem area.
- b. The frequency of occurrence and duration of storm winds from the different directions.
- c. The alignment, size, and relative geographic position of the navigation entrance to the harbor.
- d. The alignments, lengths, and locations of the various reflecting surfaces inside the harbor.
- e. The refraction of waves caused by differentials in depth in the area seaward of the harbor, which may create either a concentration or a diffusion of wave energy at the harbor site.

Wave refraction

19. When wind waves move into water of gradually decreasing depth, transformations take place in all wave characteristics except wave period (to the first order of approximation). The most important transformations with respect to the selection of test wave characteristics are the changes in wave height and direction of travel due to the phenomenon referred to as wave refraction. The change in wave height and direction may be determined by conducting a refraction analysis.

20. When the refraction coefficient (K_r) is determined, it is multiplied by the shoaling coefficient (K_s) and gives a conversion factor for transfer of deepwater wave heights to shallow-water values. The shoaling coefficient, a function of wave length and water depth, can be obtained from the Shore Protection Manual (1984). For this study, wave refraction analysis developed for prior Oceanside studies (Curren and Chatham 1980, Hales 1978) was utilized. Since the refraction diagrams for the prior studies did not cover the entire range of deepwater wave directions and periods necessary for an extreme wave analysis, they were supplemented by SPL for west and southwest wave directions.

Deepwater wave data and
selection of test waves

21. Waves approaching Oceanside Harbor can be divided into categories according to origin (USAED, Los Angeles 1989): northern hemisphere swell, southern hemisphere swell, seas generated by local winds, and seas and swell generated by eastern North Pacific tropical cyclones. Wave exposure at the site is shown in Figure 6.

22. Northern hemisphere swell, generated by extratropical cyclones of the North Pacific, approaches Oceanside from the west through narrow corridors between Santa Catalina Island, San Nicolas Island, and San Clemente Island. This swell occurs primarily during the months of November through April. These waves represent the most frequent severe waves at Oceanside.

23. Oceanside Harbor is exposed to southern hemisphere swell through a wide corridor from the south to southwest. Most of this swell arrives during the months of May through October. Because of the great decay distances, these waves have low heights and long periods. Typical southern hemisphere swell rarely exceeds 4 ft in height in deep water, with periods ranging up to 18-21 sec (USAED, Los Angeles 1989).

24. Steep, short-period waves are generated by local winds and they may occur from all offshore directions throughout the year. Fetch lengths for seas generated from the northwest are limited to a maximum of about 120 miles due to the Santa Barbara Channel Islands. Wave heights are usually between 2 and 5 ft, with an average period of 7 sec.

25. Eastern North Pacific tropical cyclones of hurricane intensity have the potential of generating some of the largest waves at Oceanside. These waves approach from the south through the southwest from May through November. However, a hurricane track along a path that would produce large waves at the site seldom occurs and was not considered in the study.

26. Measured prototype data were collected for the USAED, Los Angeles by the Coastal Data Information Program (CDIP). CDIP is a system of oceanographic measurement instruments off the west coast that measures and records real-time oceanographic data. The CDIP shallow-water station most applicable to Oceanside Harbor is the Oceanside directional slope array located approximately 1.25 miles south of the harbor complex in 30 ft of water. The 16-year record was used to determine the daily and annual wave climate. Data analysis indicated that wave heights at the entrance channel generally range up to 4 ft, but range from 8 to 10 ft, or higher, several times a year. The

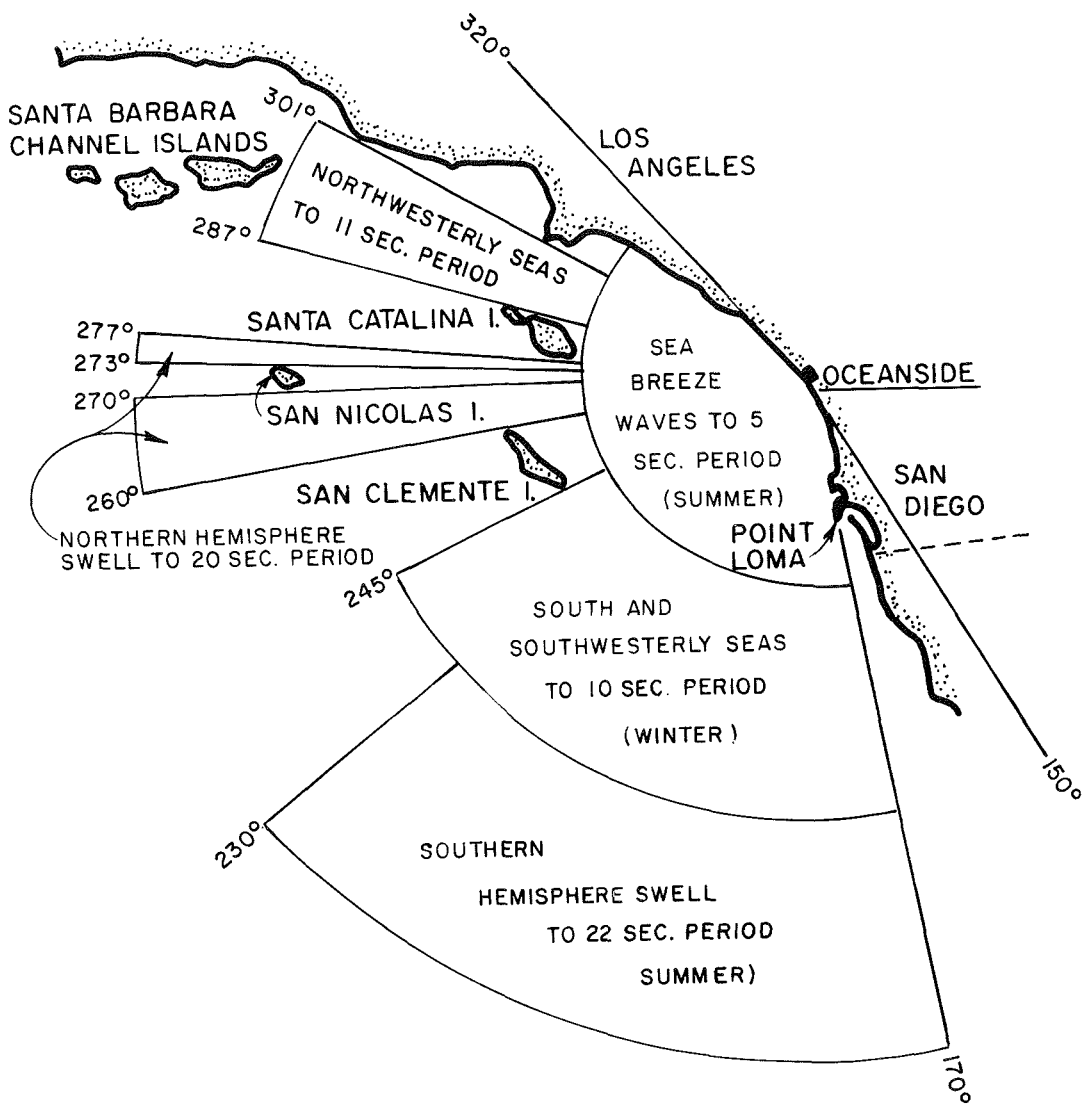


Figure 6. Oceanside Harbor storm wave exposure windows

analysis also indicated that most waves approach Oceanside Harbor from azimuths of 210-250 deg, with the majority approaching normal to shore at about 235 deg.

27. Statistical wave hindcast estimates were used (USAED, Los Angeles 1989) to develop the extreme wave conditions to be tested. These studies hindcast a combined total of 67 severe storm events during the period 1900-1983, of which 30 were selected as pertinent to Oceanside Harbor. The hindcast data set was transformed for island sheltering, refraction, shoaling, and depth limitations. An extreme value statistical analysis resulted in a set of wave conditions that were representative of various recurrence intervals.

28. Based on wave analysis conducted at the Oceanside Harbor site, SPL selected the following test wave characteristics for use in the model. These test waves were generated from directions of 210, 235, and 250 deg.

<u>Selected Test Wave *</u>	
<u>Period, sec</u>	<u>Height, ft</u>
8	4, 7, 10, 13
10	4, 7, 10, 13
12	4, 7, 13
14	10, 13, 17, 20
16	4, 7, 13, 17, 20
18	7, 10, 13
20	7, 10, 13

* All selected test waves were defined seaward of the harbor entrance at an approximate 30-ft depth.

Based on all available data, SPL determined that the following wave conditions were representative for the recurrence intervals shown.

<u>Wave Characteristic</u>	<u>Recurrence Interval</u>
8-sec, 4-ft	Weekly
14-sec, 10-ft	Annual
16-sec, 13-ft	20-yr
16-sec, 17-ft	50-yr
16-sec, 20-ft	100-yr

29. For shoaling tests, waves from 250 and 195 deg were selected to determine sediment movement patterns across the harbor entrance. These directions created longshore currents required to move the tracer material. After observing several wave conditions in the model, 14-sec, 10-ft waves were selected for use during tracer tests. These wave conditions and directions generated tracer patterns similar to those obtained in the previous model study of Oceanside Harbor (Curren and Chatham 1980).

30. Unidirectional wave spectra were generated (based on JONSWAP parameters) for most of the selected test waves and used throughout the model investigation. Plots of typical wave spectra are shown in Figure 7. The dashed line represents the desired spectra, while the solid line represents the

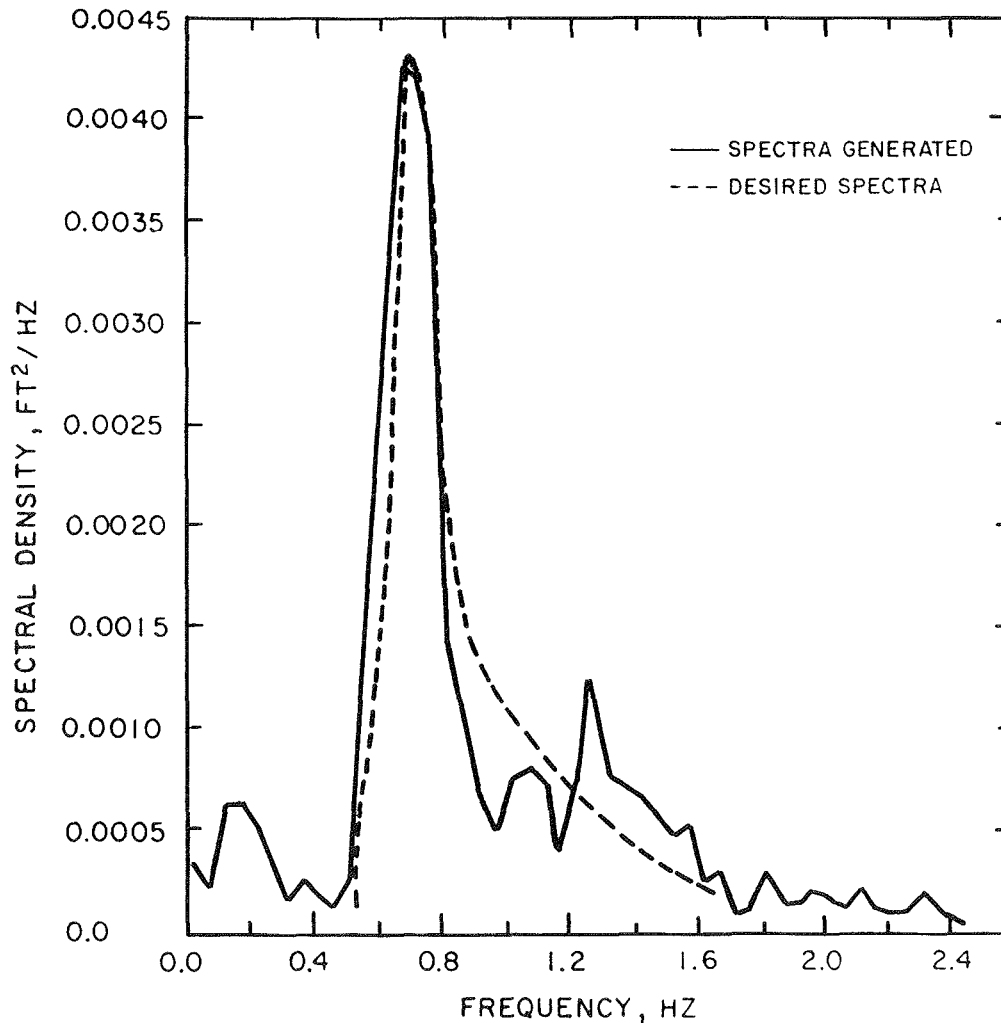


Figure 7. Typical energy density versus frequency plot (model terms) for wave spectra; 12-sec, 13-ft test waves

spectra generated by the wave machine. A typical wave train is also shown in Figure 8, which depicts water surface elevation (η) versus time. The selected test waves were significant wave heights, the average height of the highest one-third of the waves, or H_s . In deep water, H_s is very similar to H_{mo} (energy-based wave). Due to the mechanical limitations of the wave generator, monochromatic wave conditions were used to reproduce 17- and 20-ft test waves. For comparison purposes during the conduct of the study, monochromatic wave conditions and discrete spectral wave conditions representative of the site were generated for a test series. A minor change in the incoming wave direction also was examined for this series of tests.

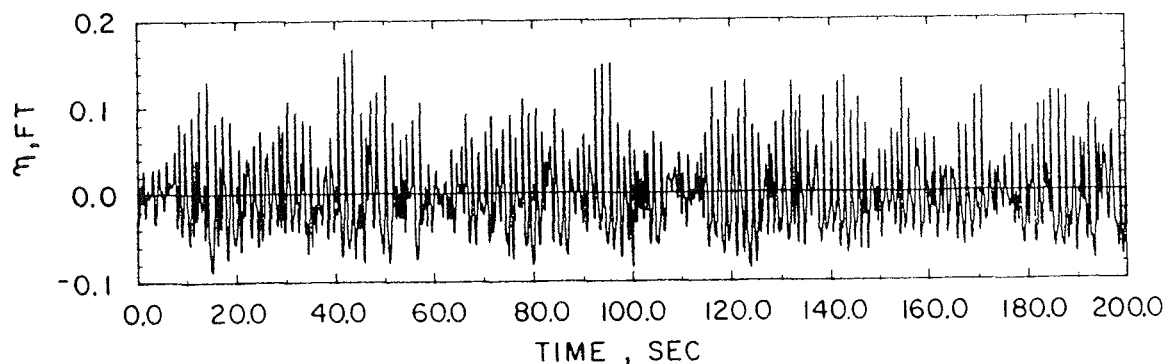


Figure 8. Typical wave train; 12-sec, 13-ft test waves

Analysis of Model Data

31. The relative merits of the various plans tested were evaluated by:

- a. Comparison of wave heights at selected locations in the model.
- b. Comparison of sediment tracer movement and subsequent deposits (for the optimum plan versus existing conditions).
- c. Visual observations and wave pattern photographs.

In the wave-height data analysis, the average height of the highest one-third of the waves (H_s) recorded at each gage location was computed. Wave heights analyzed included energy in the 0.3- to 2.2-Hz frequency band (approximately 4-30 sec prototype) in the wave spectra. All wave heights then were adjusted, by application of Keulegan's equation,* to compensate for excessive model wave height attenuation due to viscous bottom friction. From this equation, reduction of wave heights in the model (relative to the prototype) can be calculated as a function of water depth, width of wave front, wave period, water viscosity, and distance of wave travel.

* G. H. Keulegan. 1950. "The Gradual Damping of a Progressive Oscillatory Wave with Distance in a Prismatic Rectangular Channel," Unpublished data, National Bureau of Standards, Washington, DC, prepared at request of Director, WES, Vicksburg, MS, by letter of 2 May 1950.

PART IV: TESTS AND RESULTS

The Tests

Existing conditions

32. Prior to testing the various improvement plans, comprehensive tests were conducted for existing conditions (Plate 1) to establish a base from which to evaluate the effectiveness of the various improvement plans. Tests were conducted for both a shoaled entrance channel and an entrance channel dredged to authorized depths along with existing structures. Bathymetry was furnished by SPL. Wave height data were secured at various locations throughout the harbor for the selected test waves from 210, 235, and 250 deg. In addition, wave pattern photographs were obtained for representative test waves from these directions. Sediment tracer patterns were secured for a shoaled entrance condition for test waves from 195 and 250 deg.

Improvement plans

33. The originally proposed improvement plan consisted of an extension of the existing north breakwater, a spur groin extending from the existing south jetty, and an expanded entrance channel. Wave height tests and wave patterns were secured for 22 test plan configurations. Variations consisted of changes in the lengths, alignments, and crest elevations (el) of the proposed structures. Brief descriptions of the improvement plans are presented in the following subparagraphs; dimensional details are presented in Plates 2-11. Cross sections of the breakwater extension and spur are shown in Plate 12. Various structure lengths referred to below indicate lengths at the crest.

- a. Plan 1 (Plate 2) consisted of a 300-ft-long seaward extension (el +18 ft) of the north breakwater. The breakwater extension originated at the southern end of the existing structure and extended southerly. Also included was a 180-ft-long spur (el +14 ft) attached to the south jetty, which originated at the dogleg in the jetty and extended northwesterly 130 deg relative to the axis of the trunk of the jetty. This plan included an expanded entrance channel at authorized depth (-20 ft).
- b. Plan 2 (Plate 2) involved the elements of Plan 1 with a 230-ft-long jetty spur.
- c. Plan 3 (Plate 2) included the elements of Plan 1 with a 280-ft-long jetty spur.

- d. Plan 4 (Plate 3) entailed the elements of Plan 1 with a 280-ft-long jetty spur and a 350-ft-long breakwater extension.
- e. Plan 5 (Plate 3) included the elements of Plan 1 with a 280-ft-long jetty spur and a 400-ft-long breakwater extension.
- f. Plan 6 (Plate 4) involved the elements of Plan 1 with a 230-ft-long jetty spur and a 400-ft-long breakwater extension.
- g. Plan 7 (Plate 4) included the elements of Plan 1 with a 230-ft-long jetty spur and a 450-ft-long breakwater extension.
- h. Plan 8 (Plate 5) involved the elements of Plan 1 but the jetty spur was raised from an el of +14 ft to +18 ft.
- i. Plan 9 (Plate 5) entailed the elements of Plan 1 with a 230-ft-long jetty spur (el +18 ft).
- j. Plan 10 (Plate 5) included the elements of Plan 1 with a 280-ft-long jetty spur (el +18 ft).
- k. Plan 11 (Plate 6) involved the elements of Plan 1 with a 130-ft-long jetty spur (el +18 ft).
- l. Plan 12 (Plate 7) included the elements of Plan 1 with no jetty spur structure.
- m. Plan 13 (Plate 7) included the elements of Plan 1 with no jetty spur structure and a 400-ft-long breakwater extension.
- n. Plan 14 (Plate 8) involved the elements of Plan 1 but the jetty spur (el +14 ft) was reoriented to 105 deg relative to the axis of the trunk of the jetty.
- o. Plan 15 (Plate 8) entailed the elements of Plan 1 with a 230-ft-long jetty spur (el +14 ft) oriented at 105 deg relative to the axis of the trunk of the jetty.
- p. Plan 16 (Plate 9) included the elements of Plan 1 with a 230-ft-long jetty spur (el +14 ft) oriented at 105 deg relative to the axis of the jetty trunk and a 250-ft-long breakwater extension.
- q. Plan 17 (Plate 9) involved the elements of Plan 1 with the jetty spur (el +14 ft) oriented at 105 deg relative to the axis of the jetty trunk and a 250-ft-long breakwater extension.
- r. Plan 18 (Plate 9) entailed the elements of Plan 1 with the jetty spur (el +14 ft) oriented at 105 deg relative to the axis of the jetty trunk and a 200-ft-long breakwater extension.
- s. Plan 19 (Plate 10) included the elements of Plan 1 but the jetty spur was raised to an el of +18 ft and reoriented to 105 deg relative to the trunk of the jetty. The breakwater extension was 250 ft in length.
- t. Plan 20 (Plate 10) entailed the elements of Plan 1 but the jetty spur (el +18 ft) was extended to 230 ft in length and oriented 105 deg relative to the trunk of the jetty. The breakwater extension was 250 ft in length.

- u. Plan 21 (Plate 10) included the elements of Plan 1 with a 280-ft-long, +18-ft el jetty spur oriented at 105 deg relative to the jetty trunk, and a 250-ft-long breakwater extension.
- y. Plan 22 (Plate 11) involved the elements of Plan 1 but the jetty spur (el +18 ft) was extended to 280 ft in length and oriented at 105 deg relative to the jetty spur.

Wave height tests and wave patterns

34. Wave heights and representative wave patterns for the various improvement plans were obtained for test waves from one or more of the selected test directions. Tests involving most improvement plans, however, were limited to the most critical direction of wave approach (i.e., 235 deg). Although economic analyses were not carried out by CERC as part of this study, it is quite obvious that as size of proposed structures decreases, construction costs will be reduced. Thus, based on measured waves in the harbor relative to size of structure additions being proposed, it was determined by SPL that Plan 17 would be the optimum design. Plan 17 was tested comprehensively for waves from all test directions. Wave gage locations for each improvement plan are shown in Plates 2 through 11.

Sediment tracer tests

35. Sediment tracer tests were conducted for improvement Plan 17. Tracer material was introduced into the model north and south of the harbor entrance to represent sediment from those areas, respectively. During testing, a predetermined amount of sediment tracer material was fed into the model for a given time duration.

Test Results

36. In evaluating test results, the relative merits of the various plans were based on an analysis of measured wave heights in the harbor entrance, the movement of tracer material and subsequent deposits, and visual observations. Model wave heights (significant wave height or $H_{1/3}$) were tabulated to show measured values at selected locations. The general movement of tracer material and subsequent deposits were shown in photographs. Arrows were superimposed onto photographs to define sediment movement patterns.

Existing conditions

37. Preliminary wave height testing for existing conditions indicated long-period surges in the interior basins. This type of surging had been observed during a General Design Conference held at Oceanside during April

1990. Considering wave energy from all frequencies generated by the spectrum, wave heights ranging from 1.5 to 2.0 ft were common in the interior basins. Numerous expedited structural alternatives (breakwater extensions, jetty spurs, baffles, etc.) were installed in the model in an effort to reduce long-period surge conditions, but these measures proved to be ineffective. The scope of the study did not include developing a test plan to reduce long-period wave energy, which normally does not impact operations of small boat harbors. The model wave data, therefore, were filtered, and only higher frequency energy (wave periods of 30 sec or less) were analyzed for use in comparing the performance of various plans.

38. Results of wave height tests for existing conditions with the shoaled entrance channel are presented in Tables 1-3 for test waves from 250, 235, and 210 deg, respectively. For test waves from 250 deg (Table 1), maximum wave heights* were 10.5 ft in the outer entrance (gage 14) (18-sec, 13-ft test waves with the +5.4-ft swl) and 1.1 ft in the inner basins (gages 1-7) (8-sec, 13-ft and 16-sec, 17-ft test waves with the +5.4-ft swl). For weekly (8-sec, 4-ft), annual (14-sec, 10-ft), and 20-yr (16-sec, 13-ft) wave conditions from 250 deg, maximum wave heights in the inner basins were 0.4, 0.8, and 1.0 ft, respectively, all occurring for the +5.4-ft swl. For test waves from 235 deg (Table 2) maximum wave heights were 11.5 ft in the outer entrance (gage 14) (14-sec, 17-ft test waves with the +5.4-ft swl) and 1.3 ft in the inner basins (8-sec, 10-ft, 10-sec, 10-ft, and 16-sec, 17-ft test waves with the +5.4-ft swl). For weekly, annual, and 20-yr wave conditions from 235 deg, maximum wave heights were 0.5, 1.1, and 1.1 ft, respectively, in the inner basins, all for the +5.4-ft swl. Wave data obtained from 210 deg (Table 3) resulted in maximum wave heights of 9.1 ft in the outer entrance (gage 14) (14-sec, 17-ft test waves with the +5.4-ft swl) and 1.2 ft in the inner basins (8-sec, 7- and 13-ft, 16-sec, 17-ft, and 20-sec, 13-ft test waves with the +5.4-ft swl). Weekly, annual, and 20-yr wave conditions from 210 deg resulted in maximum wave heights in the inner basins of 0.3, 0.9, and 1.1 ft, respectively, all occurring with the +5.4-ft swl. Typical wave patterns obtained for existing conditions with the shoaled entrance channel are shown in Photos 1-9.

39. The general movement of tracer material and subsequent deposits obtained for existing conditions (with the shoaled entrance) for test waves

* Refers to maximum significant wave heights throughout report.

from 250 and 195 deg with the 0.0-ft swl, are shown in Photos 10 and 11. For waves from 250 deg, sediment tracer moved southerly along the breakwater and deposited in the entrance channel (Photo 10). For waves from 195 deg, tracer material moved northerly along the shoreline and deposited south of the south jetty. Tracer material moving in the breaker zone migrated around the head of the south jetty and deposited in the entrance channel (Photo 11).

40. Wave height test results for existing conditions with authorized entrance channel depths are presented in Tables 4-6 for representative test waves from 250, 235, and 210 deg, respectively. For test waves from 250 deg (Table 4), maximum wave heights were 13.1 ft in the outer entrance (gage 14) (16-sec, 17-ft test waves with the +5.4-ft swl) and 1.5 ft in the inner basins (16-sec, 17-ft and 20-sec, 10-ft test waves with the +5.4-ft swl). For weekly, annual, and 20-yr wave conditions from 250 deg, maximum wave heights in the inner basins were 0.7, 1.2, and 1.4 ft, respectively, all occurring for the +5.4-ft swl. Wave data secured from 235 deg (Table 5) resulted in maximum wave heights of 12.2 ft in the outer entrance (gage 14) (16-sec, 13-ft test waves with the +5.4-ft swl) and 1.6 ft in the inner basins for 8-sec, 10-ft, 14-sec, 13-ft, and 16-sec, 13-ft test waves with the +5.4-ft swl). Weekly, annual, and 20-yr wave conditions from 235 deg resulted in maximum wave heights of 0.8, 1.4, and 1.6 ft, respectively, in the inner basins, all occurring with the +5.4-ft swl. For test waves from 210 deg (Table 6), maximum wave heights were 15.2 ft in the outer entrance (gage 14) (10-sec, 13-ft and 16-sec, 13-ft test waves with the +5.4-ft swl) and 1.7 ft in the inner basins (16-sec, 13-ft test waves with the +5.4-ft swl). For weekly, annual, and 20-yr wave conditions from 210 deg, maximum wave heights were 0.8, 1.1, and 1.7 ft, respectively, in the inner basins, all for the +5.4-ft swl. Typical wave patterns for existing conditions with authorized entrance channel depths are shown in Photos 12-14 for the 235-deg wave direction.

41. A series of tests, requested by SPL, was conducted for existing conditions using monochromatic waves and discrete spectral wave conditions at the site. Test results in the inner harbor were compared with the JONSWAP spectral data previously obtained to determine if the harbor would be more responsive. During the test series, additional wave periods and a slight change in incident wave direction were also tested to determine changes in harbor sensitivity relative to these parameters. The discrete spectrum was double-peaked, and its shape was obtained from a prototype gage at Oceanside Pier. SPL determined that this spectrum was representative. Comparisons of

these test results are presented in Table 7. Test results indicate that there is not a significant change in response of the inner harbor basins to slight changes in wave period, wave direction, or shape of incident wave spectra. For 8-sec test waves, monochromatic conditions appeared to create slightly higher wave conditions in the basins than JONSWAP and discrete spectral conditions. JONSWAP spectral conditions, however, produced slightly higher wave conditions in the inner basins than monochromatic conditions for 10-, 14-, and 16-sec incident wave conditions.

Improvement plans

42. Wave height test results for Plan 1 are presented in Tables 8-10 for representative waves from 250, 235, and 210 deg, respectively. For test waves from 250 deg (Table 8), maximum wave heights were 7.3 ft in the outer entrance (gage 14) (16-sec, 20-ft test waves with the +5.4-ft swl) and 0.7 ft in the inner basins (16-sec, 17-ft and 20-sec, 10-ft test waves with the +5.4-ft swl). For weekly, annual, and 20-yr wave conditions from 250 deg, maximum wave heights in the inner basins were 0.3, 0.4, and 0.6 ft, respectively, all occurring for the +5.4-ft swl. Wave data secured from 235 deg (Table 9) resulted in maximum wave heights of 7.8 ft in the outer entrance (gage 14) (14-sec, 13-ft test waves with the +5.4-ft swl) and 0.8 ft in the inner basins (14-sec, 13-ft test waves with the +5.4-ft swl). Weekly, annual, and 20-yr wave conditions from 235 deg resulted in maximum wave heights in the inner basins of 0.3, 0.6, and 0.7 ft, respectively, with the +5.4-ft swl. For test waves from 210 deg (Table 10), maximum wave heights were 12.5 ft in the outer entrance (gage 14) (16-sec, 20-ft test waves with the +5.4-ft swl) and 1.0 ft in the inner basins (10-sec, 13-ft and 16-sec, 17-ft test waves with the +5.4-ft swl). For weekly wave conditions from 210 deg, maximum wave heights in the inner basins were 0.3 for both the 0.0- and +5.4-ft swl's, and for annual and 20-yr wave conditions from 210 deg, maximum wave heights were 0.6 and 0.8 ft, respectively, in the inner basins for the +5.4-ft swl. Typical wave patterns for Plan 1 are shown in Photos 15-17 for the 235-deg wave direction.

43. Wave heights obtained for Plans 2-7 are presented in Table 11 for representative test waves from 235 deg with the +5.4-ft swl. For Plans 2-7, respectively, maximum wave heights in the inner basins were 0.3, 0.3, 0.3, 0.3, 0.3, and 0.2 ft for weekly conditions; 0.5, 0.6, 0.5, 0.4, 0.4, 0.5 and 0.4 ft for annual conditions, and 0.6, 0.7, 0.7, 0.5, 0.5, 0.6 and 0.5 ft for 20-yr wave conditions.

44. Wave height data secured for Plans 8-13 are presented in Table 12 for representative test waves from 235 deg with the +5.4-ft swl. Maximum wave heights in the inner basins for Plans 8-13, respectively, were 0.3, 0.4, 0.3, 0.3, 0.3, and 0.3 for weekly conditions; 0.5, 0.5, 0.4, 0.6, 0.9, and 0.9 ft for annual conditions; and 0.6, 0.6, 0.5, 0.8, 1.4, and 1.1 ft for 20-yr wave conditions.

45. Results of wave height tests with Plans 14-18 installed are presented in Table 13 for representative waves from 235 deg with the +5.4-ft swl. Maximum wave heights in the inner basins were 0.3, 0.3, 0.3, 0.3, and 0.4 ft for weekly conditions; 0.5, 0.5, 0.5, 0.5, and 0.6 ft for annual conditions; and 0.6, 0.6, 0.6, 0.6, and 0.8 ft for 20-yr wave conditions, respectively, for Plans 14-18.

46. Wave heights obtained for Plans 19-22 are presented in Table 14 for representative test waves from 235 deg with the +5.4-ft swl. Maximum wave heights in the inner basins for Plans 19-22, respectively, were 0.3, 0.3, 0.3, and 0.2 ft for weekly conditions; 0.5, 0.5, 0.4, and 0.4 ft for annual conditions; and 0.6, 0.6, 0.5, and 0.5 ft for 20-yr wave conditions.

47. An examination of the data obtained to this point revealed that the Plan 17 configuration appeared to be optimum with respect to wave protection afforded the harbor versus size of proposed structures. Therefore, Plan 17 was reinstalled in the model and subjected to more comprehensive testing.

48. Wave height test results for Plan 17 are presented in Tables 15-17 for representative waves from 250, 235, and 210 deg, respectively. For test waves from 250 deg (Table 15), maximum wave heights were 10.0 ft in the outer entrance (gage 14) (16-sec, 20-ft test waves with the +5.4-ft swl) and 0.7 ft in the inner basins (16-sec, 17-ft test waves with the +5.4-ft swl). For weekly, annual, and 20-yr wave conditions from 250 deg, maximum wave heights in the inner basins were 0.3, 0.4, and 0.6 ft, respectively, all occurring for the +5.4-ft swl. Wave data obtained from 235 deg (Table 16) resulted in maximum wave heights of 8.8 ft in the outer entrance (gage 14) and 0.7 ft in the inner basins for 20-sec, 10-ft test waves with the +5.4-ft swl. Weekly, annual, and 20-yr wave conditions from 235 deg resulted in maximum wave heights in the inner basins of 0.3, 0.5, and 0.6 ft, respectively, for the +5.4-ft swl. For test waves from 210 deg (Table 17), maximum wave heights were 12.2 ft in the outer entrance (gage 14) (14-sec, 13-ft test waves with the +5.4-ft swl) and 0.7 ft in the inner basins for several test waves with the +5.4-ft swl. For weekly, annual, and 20-yr wave conditions from 210 deg,

maximum wave heights were 0.3, 0.5, and 0.7 ft, respectively, in the inner basins for the +5.4-ft swl. Typical wave patterns for Plan 17 are shown in Photos 18-26.

49. The general movement of tracer material and subsequent deposits obtained for Plan 17 for test waves from 250 and 195 deg with the 0.0-ft swl are shown in Photos 27 and 28. For test waves from 250 deg, sediment tracer moved southerly along the breakwater and the new extension, and deposited in the entrance channel (Photo 27). For waves from 195 deg, tracer material moved northerly along the shoreline and deposited south of the south jetty. Material moving in the breaker zone migrated around the head of the south jetty and deposited in the entrance channel (Photo 28).

Discussion of test results

50. Wave heights obtained in the inner harbor area for existing conditions indicated that the higher swl (+5.4 ft) resulted in larger wave heights than the lower swl (0.0 ft) tested for each condition. In addition, with the outer entrance dredged to authorized channel depths, larger wave heights were measured in the inner harbor basins of the model than when similar incident wave conditions were tested with the shoal in the entrance. Observations in the model indicated that waves broke on the shoal in the entrance and expended some of their energy. The deeper (dredged) entrance allowed wave energy to propagate into the harbor more readily.

51. Sediment tracer tests conducted for existing conditions indicated that sediment north of the harbor would move southerly adjacent to the north breakwater and subsequently would deposit into and across the entrance channel. Sediment south of the harbor would move northerly and eddy south of the south jetty. Some of the material eventually, however, migrated around the head of the jetty and deposited in and across the entrance channel.

52. The series of tests conducted for existing conditions with JONSWAP spectra, discrete spectra, and monochromatic waves indicated that one particular wave form was not necessarily more severe than another, considering wave conditions in the inner basins. Also, slight changes in wave period and direction resulted in no significant changes to the wave climate in the inner harbor area. It appeared that the inner basins were not extremely sensitive to minor changes in incident wave form, period, and/or direction.

53. Wave height tests conducted for the initial plan of improvement (Plan 1, 180-ft-long jetty spur and 300-ft-long breakwater extension) revealed maximum wave heights of 0.3, 0.6, and 0.8 ft in the inner harbor for weekly,

annual, and 20-yr conditions, respectively. The established wave height criteria of 0.2, 0.4, and 0.6 ft (for weekly, annual, and 20-yr conditions, respectively) were slightly exceeded. Waves from the 235- and 210-deg directions with the +5.4-ft swl resulted in the worst wave conditions in the harbor. Since wave refraction analyses and measured wave data indicated that most waves approach the harbor normal to the shoreline at Oceanside, the 235-deg direction with the +5.4-ft swl was selected for testing and comparison of additional improvement plans.

54. Of the improvement plans tested with the jetty spur on its original alignment (Plans 1-13), only the 230-ft-long jetty spur and the 450-ft-long breakwater extension of Plan 7 met the established wave height criteria. Several other plans, however, with significantly less structure length (Plans 2, 4, 5, 6, 8, and 10), resulted in wave conditions that exceeded the criteria by only 0.1 ft.

55. Of the improvement plans tested with the reoriented jetty spur (Plans 14-22), only the 280-ft-long jetty spur and the 300-ft-long breakwater extension of Plan 22 met the established wave height criteria. Other plans with less structure length (Plans 14-17 and 19-21), however, resulted in wave conditions that exceeded the wave height criteria in the inner basins by only 0.1 ft.

56. Considering wave protection afforded versus implied construction costs associated with structure size, a review of wave height data for the various test plans indicated that Plan 17 appeared to be optimal. Plan 17 entailed a 250-ft-long breakwater extension (50 ft less than the originally proposed plan (Plan 1), and a 180-ft-long spur extension (reoriented from the original plan). This plan resulted in lower wave heights in the inner harbor than the original plan; however, the weekly and annual criteria will be exceeded by 0.1 ft at one gage location (gage 7) for Plan 17. It appeared not to be economically justifiable to construct a plan that would reduce the wave height by 0.1 ft at the one gage location.

57. A comparison of wave heights obtained in the inner harbor for existing conditions (authorized entrance channel geometry and depths) and Plan 17 is shown in Plates 13-15 for weekly, annual, and 20-yr wave conditions, respectively, for the 235-deg direction with the +5.4-ft swl. As shown, wave heights were significantly reduced in the inner harbor for Plan 17. Wave height values in the inner basins for Plan 17 were, on the average, about 60 percent less than those measured for existing conditions.

58. Comprehensive test results for Plan 17 indicated that, as a result of the plan configuration, wave heights in the outer entrance (gage 14) were significantly reduced for the predominant 235-deg direction. A comparison of wave heights in the outer entrance channel (gage 14) for existing conditions (authorized entrance channel geometry and depths) and Plan 17 is shown in Plates 16 and 17 for the 0.0- and +5.4-ft swl's for various test waves from 235 deg.

59. Wave heights for Plan 17 for test waves from 250 and 210 deg indicated that the established wave height criteria for weekly, annual, and 20-yr wave conditions would be exceeded by no more than 0.1 ft at only one gage location (gage 7) in the inner basins. As discussed previously, these wave heights were acceptable by SPL, considering the cost of construction improvements required to meet the criteria versus wave protection provided.

60. Sediment tracer tests for Plan 17 revealed that sediment north of the harbor would move southerly adjacent to the north breakwater and around the new breakwater extension into, but not across, the entrance channel. Material south of the harbor would move northerly adjacent to the south jetty. Material in the breaker zone migrated around the head of the jetty and into, but not across, the entrance channel. Sediment patterns for Plan 17 were similar to those for existing conditions, except that the tracer material did not penetrate as deeply into the entrance as it did for existing conditions. The head of the Plan 17 breakwater extension was located more seaward than the existing structure, which caused the sediment to deposit at a more seaward location. Material moving around the south jetty head appeared to feel the influence of reflected waves off the spur of Plan 17, which prevented it from penetrating as far into the inner portions of the entrance channel.

61. Preliminary wave height testing in the model showed that incident wave spectra caused long-period surging of the inner basins. Various structural alternatives were installed and proved to be ineffective in reducing these conditions. The installation of the Plan 17 structures is not expected to either worsen, or improve, any adverse long-period wave conditions that may exist in the harbor. Generally, long-period wave energy does not impact operation in small-boat harbors.

PART V: CONCLUSIONS

62. Based on the results of the coastal hydraulic model investigation reported herein, it is concluded that:

- a. For the existing harbor configuration, wave heights in the inner harbor were more severe during periods when the shoal in the entrance channel was not present. With the shoaled entrance, waves broke and expended some of their energy, while with the dredged entrance (authorized depths), more wave energy propagated into the harbor.
- b. The originally proposed improvement plan (Plan 1, 180-ft-long jetty spur (el +14 ft) and 300-ft-long breakwater extension (el +18 ft)) will result in wave conditions in the inner harbor in excess of the established criteria (0.2, 0.4, and 0.6 ft for weekly, annual, and 20-yr wave conditions, respectively).
- c. Of the improvement plans tested with the jetty spur on its original alignment (Plans 1-13), only the 230-ft-long jetty spur and the 450-ft-long breakwater extension of Plan 7 met the established wave height criteria.
- d. Of the improvement plans tested with the reoriented jetty spur (Plans 14-22), only the 280-ft-long jetty spur and the 300-ft-long breakwater extension of Plan 22 met the established wave height criteria.
- e. Of all the improvement plans tested from 235 deg, and considering wave protection afforded versus volume of construction materials, the 180-ft-long jetty spur and the 250-ft-long breakwater extension of Plan 17 were considered optimal. The wave height criteria will be exceeded by 0.1 ft at only one gage location in the inner harbor for weekly and annual wave conditions.
- f. The Plan 17 harbor configuration will result in wave heights in the inner harbor that are 60 percent less, on the average, than those obtained for existing conditions (with authorized channel depths) for test waves from the more predominant 235-deg direction.
- g. Wave heights in the outer entrance will be reduced as a result of the installation of Plan 17 for test waves from the more predominant 235-deg direction.
- h. Considering test waves from the 250- and 210-deg directions, the wave height criteria in the inner harbor will be exceeded by only 0.1 ft at one gage location for weekly, annual, and/or 20-yr wave conditions when Plan 17 is in place.
- i. The installation of the Plan 17 structures should not impact sediment patterns on a regional basis. Sediment will continue to move into the entrance, but it will deposit more seaward in the expanded entrance and will not penetrate as deeply into the entrance channel.

- j. Model results indicate that installation of Plan 17 will not have any impact on long-period wave conditions in the inner harbor basins.

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Table 1

Wave Heights for Existing Conditions with Shoal in Entrance
for Test Waves from 250 deg

Test Wave		Wave Height, ft, Gage Number															
Period	Height	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
sec	ft																
swl = 0.0 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	2.8	2.3	0.5	0.3	3.7	2.5	3.6	3.9
	7	0.1	0.1	0.2	0.2	0.2	0.1	0.4	0.8	5.1	4.7	0.8	0.4	6.2	4.5	7.2	7.0
	10	0.2	0.2	0.3	0.2	0.3	0.2	0.5	1.1	5.1	5.8	1.1	0.4	9.3	4.6	7.2	9.7
	13	0.3	0.3	0.4	0.3	0.4	0.3	0.6	1.2	5.2	5.6	1.5	0.5	7.1	4.4	7.2	13.6
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	4.3	3.4	0.8	0.4	5.5	3.2	5.5	4.1
	7	0.2	0.2	0.3	0.2	0.3	0.2	0.5	1.0	5.5	5.8	1.1	0.4	8.6	4.9	8.0	7.1
	10	0.2	0.2	0.3	0.3	0.4	0.2	0.5	1.1	5.2	6.2	1.3	0.4	9.4	4.6	7.6	9.9
	13	0.3	0.2	0.3	0.3	0.5	0.3	0.6	1.2	5.5	6.0	1.6	0.5	8.1	4.6	7.3	13.9
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	3.9	2.8	1.0	0.4	5.2	3.2	5.4	4.3
	7	0.1	0.1	0.2	0.2	0.3	0.2	0.4	0.8	6.0	5.2	1.2	0.5	7.4	5.3	8.2	7.3
	13	0.3	0.3	0.3	0.3	0.5	0.3	0.6	1.2	5.7	6.0	1.4	0.6	11.0	4.4	8.2	13.4
14	10	0.2	0.2	0.3	0.3	0.4	0.3	0.4	0.9	5.7	5.7	1.2	0.5	9.6	4.6	7.8	10.0
	13	0.3	0.3	0.3	0.4	0.5	0.4	0.6	1.0	5.7	6.2	1.4	0.5	11.6	4.7	8.4	13.3
	17	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	4.9	5.1	2.0	0.4	7.0	3.2	6.5	16.3
	20	0.1	0.1	0.2	0.1	0.1	0.1	0.4	0.9	5.4	5.9	2.1	0.5	6.7	3.3	7.7	15.7
16	4	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.4	3.3	2.3	0.8	0.4	4.3	3.0	4.8	3.9
	7	0.2	0.2	0.2	0.3	0.4	0.2	0.4	0.8	5.8	4.6	1.1	0.5	7.8	4.9	7.8	7.1
	13	0.2	0.3	0.3	0.3	0.5	0.3	0.6	1.0	5.8	6.4	1.6	0.6	11.6	5.7	8.5	14.1
	17	0.1	0.1	0.1	0.2	0.1	0.1	0.5	0.7	5.3	4.4	1.9	0.5	13.2	3.2	5.8	16.9
18	7	0.3	0.2	0.2	0.3	0.3	0.2	0.4	0.7	6.1	4.2	1.1	0.5	7.1	5.3	7.8	7.4
	10	0.3	0.2	0.3	0.3	0.4	0.2	0.5	1.0	6.9	5.8	1.2	0.5	9.0	6.1	8.9	9.8
	13	0.3	0.3	0.3	0.4	0.5	0.3	0.6	1.0	6.3	7.0	1.5	0.6	11.0	6.0	8.4	13.0
20	7	0.3	0.3	0.2	0.3	0.3	0.2	0.4	0.8	6.6	5.2	1.1	0.5	8.0	5.8	7.9	7.4
	10	0.3	0.2	0.3	0.3	0.4	0.3	0.5	1.0	7.2	6.7	1.4	0.6	10.1	6.1	9.2	10.3
	13	0.2	0.2	0.3	0.2	0.3	0.2	0.5	0.9	6.1	6.6	1.3	0.6	8.7	4.6	8.1	12.4

(Continued)

Table 1 (Concluded)

Test Wave		Wave Height, ft., Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.1	0.2	0.1	0.1	0.1	0.4	0.6	3.0	2.7	1.0	0.6	3.8	3.0	3.6	3.7
	7	0.1	0.1	0.2	0.2	0.2	0.1	0.6	1.0	5.9	4.6	1.3	0.8	7.0	4.8	6.0	6.5
	10	0.2	0.3	0.5	0.3	0.4	0.2	0.9	1.6	6.6	7.3	1.8	0.8	8.8	6.6	7.4	10.3
	13	0.3	0.4	0.6	0.4	0.7	0.4	1.1	1.9	7.4	8.0	2.4	1.1	11.5	6.8	7.9	13.7
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.6	3.2	2.6	1.4	0.8	3.9	3.0	3.7	3.9
	7	0.2	0.2	0.3	0.3	0.4	0.2	0.6	1.1	6.8	5.2	2.0	1.1	7.0	5.5	6.8	7.0
	10	0.2	0.3	0.5	0.4	0.6	0.3	0.9	1.6	7.8	7.4	2.1	1.2	8.8	6.9	7.9	10.3
	13	0.2	0.4	0.5	0.4	0.7	0.3	0.9	1.6	8.9	10.7	2.3	1.2	12.0	8.2	10.1	13.1
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	3.3	2.6	1.4	0.8	4.0	3.3	4.4	4.1
	7	0.2	0.3	0.3	0.4	0.4	0.2	0.5	1.0	7.2	4.9	2.0	1.1	7.4	5.8	8.5	7.1
	13	0.3	0.4	0.5	0.5	0.7	0.4	0.9	1.5	9.3	10.6	2.3	1.3	12.1	8.1	11.2	13.0
14	10	0.3	0.3	0.4	0.4	0.5	0.2	0.8	1.4	8.7	8.5	2.2	1.1	9.6	7.3	9.9	10.3
	13	0.3	0.5	0.5	0.6	0.7	0.5	1.0	1.7	10.5	10.4	2.9	1.6	11.3	9.3	12.8	13.2
	17	0.2	0.3	0.4	0.2	0.3	0.2	0.5	2.1	9.4	11.5	2.4	0.9	19.4	6.7	10.5	17.2
	20	0.3	0.3	0.3	0.2	0.3	0.2	0.5	1.6	8.8	9.0	2.6	0.9	18.3	6.2	8.7	19.0
16	4	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.7	4.0	2.6	1.6	1.0	3.6	3.6	4.7	4.1
	7	0.4	0.4	0.4	0.5	0.5	0.4	0.6	1.2	7.6	4.7	2.2	1.3	6.2	6.1	8.8	7.2
	13	0.4	0.5	0.5	0.7	0.8	0.5	1.0	1.7	11.7	9.2	2.8	1.6	14.5	9.8	13.1	13.2
	17	0.2	0.2	0.3	0.5	0.3	0.2	1.1	1.4	8.6	8.7	3.7	2.1	16.2	6.1	8.5	16.8
18	20	0.2	0.2	0.4	0.5	0.3	0.3	1.0	1.5	9.2	8.4	3.8	2.0	30.2	6.2	8.1	20.2
	7	0.4	0.4	0.4	0.5	0.6	0.4	0.6	1.2	7.4	4.2	2.2	1.3	7.4	7.0	7.8	7.4
	10	0.5	0.5	0.5	0.7	0.8	0.5	0.8	1.6	9.9	5.8	2.5	1.5	9.9	8.7	10.3	10.0
	13	0.4	0.6	0.6	0.7	0.9	0.5	1.0	1.9	12.4	10.1	3.0	1.6	14.1	10.5	13.4	13.7
20	7	0.3	0.4	0.5	0.5	0.6	0.4	0.7	1.2	7.7	4.1	2.1	1.3	6.8	6.4	7.8	7.4
	10	0.3	0.5	0.5	0.6	0.7	0.4	0.8	1.4	8.7	5.6	2.2	1.3	7.9	7.9	9.4	10.7
	13	0.4	0.4	0.5	0.6	0.9	0.4	0.9	1.5	9.7	9.2	2.5	1.4	9.2	8.6	10.7	13.0

Table 2

Wave Heights for Existing Conditions with Shoal in Entrance
for Test Waves from 235 deg

<u>Test Wave</u>		<u>Wave Height, ft, Gage Number</u>															
<u>Period</u>	<u>Height</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
<u>sec</u>	<u>ft</u>																
<u>swl = 0.0 ft</u>																	
8	4	0.1	0.1	0.2	0.2	0.2	0.1	0.4	0.7	3.3	2.7	0.7	0.2	3.6	4.5	3.9	3.9
	7	0.2	0.2	0.3	0.3	0.3	0.2	0.6	1.2	6.0	5.4	1.3	0.4	6.4	5.7	7.5	7.0
	10	0.2	0.3	0.4	0.3	0.4	0.2	0.8	1.4	5.9	5.6	1.5	0.5	8.2	6.1	7.9	10.2
	13	0.3	0.3	0.4	0.4	0.6	0.4	0.7	1.3	6.3	6.0	2.0	0.7	9.2	5.7	8.4	13.4
10	4	0.1	0.2	0.2	0.2	0.2	0.1	0.4	0.8	4.3	2.7	1.0	0.3	4.4	5.2	4.6	4.2
	7	0.2	0.3	0.4	0.3	0.5	0.3	0.6	1.3	6.9	6.1	1.4	0.5	6.9	6.4	9.1	7.1
	10	0.4	0.4	0.5	0.4	0.6	0.4	0.7	1.4	6.7	6.4	1.8	0.6	8.3	6.1	9.3	10.8
	13	0.4	0.4	0.5	0.4	0.6	0.4	0.8	1.5	6.5	6.5	1.8	0.6	10.3	6.0	9.0	13.1
12	4	0.2	0.2	0.3	0.2	0.3	0.2	0.4	0.9	4.6	3.0	1.0	0.4	4.4	5.8	5.8	4.0
	7	0.3	0.4	0.4	0.4	0.5	0.3	0.7	1.3	7.2	6.6	1.5	0.6	7.7	6.8	10.0	7.5
	13	0.4	0.4	0.5	0.5	0.7	0.4	0.8	1.5	6.9	6.8	1.9	0.7	10.6	6.6	9.5	13.4
14	10	0.4	0.4	0.5	0.5	0.7	0.4	0.7	1.3	7.3	7.3	1.4	0.7	10.8	6.9	9.2	10.9
	13	0.5	0.5	0.5	0.6	0.8	0.5	0.8	1.4	7.4	7.6	1.8	0.7	12.2	7.2	10.0	13.7
	17	0.1	0.1	0.3	0.2	0.2	0.1	0.5	0.9	7.4	7.5	1.7	0.6	8.8	5.9	6.9	17.2
	20	0.1	0.1	0.3	0.1	0.1	0.1	0.3	0.9	7.1	6.2	1.4	0.5	7.6	5.3	5.8	18.5
16	4	0.2	0.2	0.2	0.3	0.3	0.2	0.4	0.8	4.9	3.2	1.1	0.4	5.0	5.8	6.0	4.1
	7	0.3	0.3	0.4	0.4	0.4	0.4	0.7	1.2	7.6	6.5	1.5	0.5	8.6	7.4	9.4	7.2
	13	0.4	0.4	0.5	0.4	0.7	0.5	0.8	1.4	7.4	7.5	1.8	0.7	12.3	7.2	9.6	13.9
	17	0.1	0.2	0.2	0.3	0.2	0.1	0.5	0.9	7.5	6.3	2.1	0.6	11.7	5.2	7.2	17.2
	20	0.3	0.3	0.4	0.7	0.4	0.3	1.2	2.1	12.1	12.8	4.4	2.3	10.8	8.3	14.3	20.3
18	7	0.3	0.4	0.4	0.5	0.6	0.3	0.6	1.1	7.7	6.7	1.5	0.5	8.7	7.1	9.1	7.4
	10	0.4	0.4	0.4	0.5	0.6	0.3	0.7	1.2	7.7	7.7	1.6	0.6	10.0	6.9	10.5	10.3
	13	0.5	0.4	0.5	0.5	0.6	0.4	0.7	1.4	7.8	7.9	1.7	0.7	10.9	7.2	9.9	13.7
20	7	0.4	0.4	0.4	0.5	0.5	0.3	0.7	1.1	8.1	6.2	1.5	0.6	8.5	7.4	9.8	7.4
	10	0.3	0.4	0.5	0.6	0.7	0.4	0.8	1.2	8.7	8.4	1.6	0.6	9.7	7.4	10.4	10.4
	13	0.4	0.5	0.5	0.6	0.7	0.5	0.8	1.4	8.5	8.4	2.0	0.7	10.8	7.5	10.2	13.6

(Continued)

Table 2 (Concluded)

Test Wave		Wave Height, ft., Gage Number															
Period	Height	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
sec	ft																
swl = +5.4 ft																	
8	4	0.1	0.2	0.3	0.2	0.1	0.1	0.5	0.9	3.6	3.3	1.2	0.8	4.0	4.0	3.6	3.8
	7	0.2	0.3	0.6	0.3	0.3	0.1	1.1	1.9	6.2	5.5	1.8	1.0	7.3	7.4	7.2	6.9
	10	0.3	0.4	0.8	0.4	0.4	0.2	1.3	2.3	8.8	8.3	2.4	1.2	11.0	8.7	10.8	10.0
	13	0.3	0.5	0.7	0.4	0.5	0.4	1.2	2.0	8.8	9.2	2.8	1.2	14.3	8.4	11.3	13.3
10	4	0.1	0.2	0.3	0.2	0.2	0.1	0.6	0.8	4.0	3.4	1.5	1.0	4.1	5.3	5.0	4.1
	7	0.3	0.4	0.6	0.4	0.5	0.3	1.1	1.7	7.6	6.5	2.0	1.2	7.2	9.0	9.5	7.1
	10	0.4	0.5	0.7	0.5	0.7	0.4	1.3	2.2	9.2	9.2	2.5	1.4	9.9	10.6	11.8	9.9
	13	0.4	0.5	0.8	0.6	0.8	0.4	1.2	1.8	11.1	10.1	2.9	1.2	12.2	9.7	13.1	13.2
12	4	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.7	4.7	3.1	1.7	0.8	4.3	5.0	5.3	4.1
	7	0.3	0.4	0.5	0.4	0.5	0.3	0.8	1.4	8.6	6.2	2.1	1.0	8.6	8.8	9.8	7.3
	13	0.4	0.5	0.7	0.6	0.7	0.4	1.1	1.7	11.0	9.9	3.0	1.4	13.2	9.7	13.4	13.2
14	10	0.4	0.5	0.7	0.7	0.9	0.4	1.1	1.9	10.1	9.0	3.0	1.2	9.4	7.8	11.5	10.5
	13	0.4	0.6	0.7	0.6	0.8	0.5	1.1	1.8	9.3	9.5	3.3	1.3	12.2	7.4	10.6	12.7
	17	0.3	0.3	0.5	0.4	0.5	0.3	0.6	2.0	17.5	11.5	2.7	1.1	11.4	11.5	13.9	17.4
	20	0.2	0.3	0.3	0.3	0.4	0.3	0.5	2.0	11.5	10.1	2.6	1.0	19.3	9.3	9.8	20.7
16	4	0.3	0.3	0.3	0.4	0.4	0.3	0.5	1.0	4.4	3.3	2.0	1.2	4.8	5.1	5.3	4.2
	7	0.4	0.5	0.5	0.6	0.6	0.4	0.9	1.6	7.7	6.4	2.5	1.3	8.2	8.2	9.8	7.3
	13	0.4	0.6	0.6	0.6	0.8	0.5	1.1	1.9	10.1	10.2	3.2	1.5	13.9	9.2	14.0	13.3
	17	0.2	0.3	0.4	0.6	0.4	0.3	1.3	2.1	11.0	14.4	4.6	1.8	15.2	9.3	19.1	16.3
	20	0.3	0.3	0.4	0.7	0.4	0.3	1.2	2.1	12.1	12.9	4.6	2.3	10.8	8.3	14.3	20.3
18	7	0.4	0.5	0.5	0.7	0.7	0.4	0.9	1.5	7.8	5.5	2.7	1.2	6.0	8.0	7.3	7.3
	10	0.4	0.5	0.6	0.7	0.9	0.4	1.0	1.7	9.9	8.0	3.1	1.4	8.5	9.7	9.9	10.4
	13	0.4	0.7	0.6	0.7	1.1	0.5	1.1	1.9	10.2	10.2	3.3	1.7	11.6	10.1	12.5	13.1
20	7	0.4	0.5	0.5	0.6	0.6	0.4	1.0	1.4	7.6	4.9	2.5	1.2	6.3	7.3	7.4	7.0
	10	0.4	0.5	0.6	0.6	0.7	0.4	1.1	1.7	9.7	7.8	3.0	1.2	8.3	8.6	9.3	10.5
	13	0.4	0.5	0.7	0.6	0.9	0.4	1.1	1.8	10.0	9.7	3.2	1.3	9.5	8.9	9.8	13.4

Table 3

Wave Heights for Existing Conditions with Shoal in Entrance
for Test Waves from 210 deg

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.8	4.4	5.4	1.0	0.3	3.6	3.9	4.3	3.7
	7	0.2	0.3	0.4	0.3	0.3	0.2	0.5	1.1	6.9	6.5	2.3	0.4	6.8	4.7	6.6	7.3
	10	0.3	0.3	0.4	0.3	0.5	0.3	0.6	1.1	7.8	6.9	2.5	0.5	8.5	5.1	7.7	9.9
	13	0.5	0.4	0.5	0.5	0.7	0.4	0.9	1.5	7.3	5.8	2.5	0.8	10.1	5.7	8.7	13.9
10	4	0.2	0.2	0.3	0.2	0.2	0.1	0.6	1.1	4.7	5.6	1.4	0.4	4.3	5.3	5.2	4.3
	7	0.2	0.2	0.3	0.3	0.4	0.2	0.5	1.1	6.8	6.3	2.4	0.6	7.5	4.9	7.9	7.3
	10	0.4	0.3	0.4	0.4	0.6	0.3	0.7	1.2	7.3	6.2	2.4	0.7	9.8	5.0	9.0	10.6
	13	0.5	0.5	0.5	0.6	0.9	0.5	0.8	1.4	7.5	6.4	2.5	0.7	10.0	5.3	9.2	13.4
12	4	0.2	0.2	0.2	0.3	0.3	0.2	0.4	0.9	5.0	5.6	1.6	0.4	4.2	4.9	5.0	4.3
	7	0.3	0.3	0.4	0.4	0.5	0.3	0.5	1.0	7.3	6.2	2.4	0.7	7.2	5.2	8.3	7.4
	13	0.5	0.5	0.6	0.6	0.8	0.6	0.8	1.5	8.1	6.8	2.6	0.8	11.4	6.2	10.0	13.8
14	10	0.4	0.4	0.4	0.5	0.8	0.3	0.6	1.2	7.6	6.0	2.5	0.6	9.3	5.6	9.6	10.8
	13	0.5	0.5	0.5	0.6	1.0	0.6	0.7	1.4	8.0	6.1	2.7	0.7	11.4	5.8	9.8	13.9
	17	0.1	0.1	0.3	0.2	0.2	0.1	0.4	0.9	8.0	5.5	2.8	0.7	14.8	6.1	11.1	17.5
	20	0.1	0.1	0.2	0.2	0.2	0.1	0.4	0.9	6.7	6.5	3.2	0.7	14.2	6.4	10.1	20.4
16	4	0.2	0.2	0.2	0.3	0.3	0.2	0.4	0.8	5.3	4.8	1.4	0.4	3.5	4.8	4.0	4.3
	7	0.3	0.3	0.3	0.4	0.5	0.3	0.6	1.0	7.7	6.3	2.2	0.6	7.4	5.8	8.0	7.4
	13	0.5	0.4	0.5	0.5	0.8	0.5	0.8	1.3	8.2	6.5	3.2	0.8	11.2	6.0	10.7	13.0
	17	0.2	0.2	0.3	0.3	0.3	0.2	0.7	1.6	6.0	8.4	3.2	0.9	13.4	5.9	10.9	17.2
	20	0.1	0.2	0.3	0.3	0.2	0.1	0.6	1.2	6.0	8.2	2.8	0.8	13.9	5.9	10.5	19.4
18	7	0.4	0.4	0.4	0.5	0.6	0.3	0.6	1.0	7.8	6.6	2.3	0.6	7.6	6.2	7.7	7.2
	10	0.3	0.4	0.4	0.5	0.7	0.4	0.6	1.1	7.5	6.2	2.6	0.7	9.0	5.8	9.5	10.5
	13	0.5	0.5	0.5	0.6	0.7	0.4	0.8	1.4	7.1	6.7	2.6	0.8	11.1	5.8	9.6	12.9
20	7	0.4	0.4	0.3	0.5	0.6	0.3	0.6	1.0	7.9	6.5	2.4	0.6	6.7	5.7	8.4	7.2
	10	0.4	0.4	0.4	0.5	0.7	0.4	0.7	1.2	8.2	6.8	2.6	0.7	9.1	5.8	9.8	10.5
	13	0.4	0.4	0.4	0.5	0.7	0.4	0.7	1.3	7.6	6.7	2.8	0.8	10.1	5.9	10.7	13.4

(Continued)

Table 3 (Concluded)

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>swl = +5.4 ft</u>																	
8	4	0.1	0.1	0.1	0.2	0.1	0.1	0.3	1.0	3.8	4.7	1.4	0.6	3.9	4.1	4.0	4.1
	7	0.2	0.3	0.6	0.4	0.3	0.2	1.2	2.0	6.7	8.1	2.3	1.0	7.1	7.1	7.3	7.1
	10	0.3	0.3	0.6	0.4	0.6	0.3	1.1	1.9	9.0	9.2	3.8	1.5	9.9	7.3	10.0	10.1
	13	0.4	0.5	0.7	0.6	1.0	0.4	1.2	2.1	10.0	10.7	3.9	1.6	12.8	8.4	11.4	12.8
10	4	0.1	0.2	0.4	0.2	0.2	0.1	0.7	1.3	3.6	5.3	1.9	1.0	4.0	4.7	4.0	4.0
	7	0.2	0.3	0.5	0.4	0.6	0.2	1.1	1.9	7.2	9.3	3.0	1.5	7.1	7.4	7.3	7.1
	10	0.3	0.4	0.5	0.5	0.8	0.3	1.0	1.7	10.7	10.2	4.5	1.5	9.7	7.2	9.4	10.0
	13	0.5	0.5	0.6	0.6	0.9	0.5	1.1	1.8	10.7	9.9	4.1	1.6	12.4	7.4	11.9	13.3
12	4	0.1	0.2	0.2	0.2	0.3	0.1	0.5	1.0	3.3	5.4	2.0	0.9	3.3	4.6	3.7	4.1
	7	0.2	0.3	0.4	0.4	0.5	0.2	0.7	1.4	5.8	8.1	2.8	1.2	5.3	5.8	6.1	7.2
	13	0.5	0.6	0.6	0.7	0.9	0.5	1.0	1.8	11.0	10.2	4.5	1.6	10.4	6.5	11.1	13.4
14	10	0.3	0.3	0.5	0.4	0.6	0.2	0.9	1.7	8.2	9.5	3.6	1.4	8.3	5.8	8.5	10.1
	13	0.5	0.5	0.7	0.7	0.8	0.6	1.1	1.8	11.3	10.7	4.1	1.7	12.0	7.3	11.9	13.4
	17	0.3	0.3	0.6	0.4	0.4	0.3	1.0	2.2	12.8	9.1	4.1	2.0	20.8	9.1	12.5	16.9
	20	0.3	0.3	0.5	0.3	0.3	0.2	0.7	2.1	12.4	9.5	4.4	2.2	24.7	7.6	15.5	20.0
16	4	0.3	0.3	0.3	0.6	0.3	0.3	0.7	1.2	5.4	4.9	2.6	1.0	3.9	5.1	4.6	4.2
	7	0.4	0.4	0.5	0.6	0.6	0.4	0.9	1.6	9.0	9.1	3.6	1.4	7.1	7.6	8.3	7.3
	13	0.4	0.6	0.6	0.7	0.9	0.6	1.1	1.8	12.5	10.3	4.8	1.6	13.0	8.1	13.1	13.0
	17	0.6	0.5	0.7	0.5	0.6	0.5	1.2	2.2	12.6	9.0	4.1	2.0	20.6	8.9	12.2	16.9
	20	0.2	0.3	0.4	0.5	0.3	0.3	1.0	1.6	9.5	12.5	3.8	1.9	12.7	7.8	12.8	20.4
18	7	0.5	0.6	0.5	0.8	0.8	0.5	1.0	1.7	8.7	8.8	4.0	1.4	6.8	8.2	7.4	7.3
	10	0.5	0.6	0.6	0.8	0.9	0.5	1.1	1.8	11.7	9.8	4.6	1.5	9.2	8.5	10.2	10.5
	13	0.5	0.7	0.6	0.8	1.0	0.6	1.1	1.9	11.4	10.3	4.8	1.5	11.2	8.5	12.1	13.3
20	7	0.5	0.7	0.7	0.8	0.9	0.6	1.1	1.9	8.9	9.2	4.0	1.4	6.8	8.3	8.6	7.3
	10	0.4	0.7	0.6	0.8	0.9	0.5	1.1	1.9	11.1	10.3	4.8	1.5	9.4	8.5	11.1	10.8
	13	0.4	0.8	0.8	0.8	1.1	0.6	1.2	2.0	11.0	10.4	5.0	1.6	10.9	8.7	12.7	13.8

Table 4

Wave Heights for Existing Conditions with Authorized Channel Depths
for Test Waves from 250 deg

Test Wave		Wave Height, ft., Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.3	0.3	0.2	0.1	0.1	0.6	0.9	4.6	2.7	0.8	0.3	4.9	4.3	3.7	4.2
	10	0.3	0.5	0.5	0.4	0.4	0.3	1.2	2.0	6.0	6.8	1.6	0.6	8.9	8.9	8.0	10.5
10	4	0.1	0.2	0.2	0.2	0.1	0.1	0.4	0.7	5.5	2.3	1.2	0.3	4.7	3.0	4.2	4.2
	7	0.2	0.4	0.3	0.3	0.2	0.1	0.7	1.2	6.9	5.3	1.6	0.6	7.8	5.5	7.1	7.4
	10	0.3	0.4	0.4	0.4	0.4	0.2	0.9	1.4	7.8	6.9	1.8	0.7	8.9	7.6	9.0	10.2
	13	0.3	0.5	0.5	0.5	0.7	0.4	1.2	1.9	8.6	8.0	2.4	0.8	9.5	9.7	11.3	13.6
12	4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.6	6.7	2.6	1.3	0.5	3.8	3.8	3.8	4.1
	7	0.2	0.3	0.3	0.3	0.3	0.2	0.6	1.1	8.5	5.3	1.9	0.7	7.0	6.4	6.7	7.1
	13	0.5	0.6	0.5	0.6	0.8	0.6	1.2	1.8	10.1	8.7	2.5	0.9	9.8	10.4	12.0	13.2
14	10	0.4	0.5	0.4	0.5	0.7	0.4	0.7	1.2	9.9	7.1	2.4	0.9	10.4	7.6	8.5	9.7
	13	0.6	0.5	0.5	0.6	0.7	0.6	1.0	1.6	9.0	7.4	2.5	0.9	10.4	7.6	10.5	12.7
16	4	0.1	0.2	0.1	0.2	0.2	0.1	0.3	0.5	6.7	2.3	1.3	0.5	5.5	3.1	4.2	4.1
	7	0.3	0.4	0.3	0.4	0.5	0.3	0.6	0.9	9.1	4.8	2.2	0.7	10.3	5.4	7.3	7.3
	13	0.5	0.7	0.6	0.7	1.0	0.6	1.1	1.8	9.5	8.2	3.6	1.1	13.4	8.5	12.7	13.5
	17	0.2	0.3	0.4	0.5	0.5	0.4	0.9	1.2	8.9	5.5	2.6	1.0	11.6	9.3	12.7	17.4
	20	0.2	0.3	0.4	0.6	0.6	0.5	0.9	1.3	8.8	6.9	2.5	1.2	11.0	8.5	9.9	20.1
18	7	0.4	0.4	0.3	0.4	0.4	0.4	0.6	0.8	9.1	4.0	2.3	0.7	9.5	4.9	6.5	6.7
	10	0.5	0.5	0.4	0.6	0.7	0.5	0.9	1.3	10.0	7.1	2.9	0.9	11.5	7.2	10.2	10.5
20	7	0.5	0.5	0.4	0.5	0.5	0.4	0.7	1.0	7.9	4.8	1.9	0.7	8.5	5.2	6.9	7.0
	10	0.5	0.6	0.5	0.6	0.6	0.5	0.9	1.4	9.0	6.6	2.3	0.8	9.2	7.5	10.0	10.7

(Continued)

Table 4 (Concluded)

Test Wave		Wave Height, ft., Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.3	0.3	0.2	0.1	0.4	0.7	1.0	6.1	2.8	1.3	0.8	4.9	4.1	4.2	4.3
	10	0.3	0.5	0.6	0.5	0.4	0.4	1.3	2.0	10.6	7.7	2.2	1.3	10.1	9.4	10.0	10.8
10	4	0.1	0.3	0.2	0.2	0.1	0.2	0.5	0.7	6.3	2.2	1.6	0.9	3.5	3.9	3.7	3.8
	7	0.2	0.3	0.4	0.3	0.2	0.2	0.8	1.3	11.0	4.5	2.4	1.2	6.2	7.1	6.6	6.9
	10	0.3	0.6	0.6	0.4	0.5	0.3	1.2	1.9	11.2	7.8	3.1	1.5	9.5	10.1	9.7	10.4
	13	0.4	0.6	0.6	0.5	0.6	0.4	1.4	2.1	12.8	9.1	3.4	1.7	10.5	11.1	11.4	12.9
12	4	0.1	0.2	0.1	0.2	0.1	0.2	0.3	0.7	5.0	2.2	1.9	1.0	3.6	3.5	3.5	3.8
	7	0.2	0.3	0.3	0.3	0.3	0.2	0.7	1.3	9.3	4.4	3.0	1.4	7.3	6.6	6.8	7.3
	13	0.4	0.6	0.6	0.6	0.9	0.5	1.2	2.2	11.3	9.6	3.8	1.8	12.2	10.8	11.6	13.2
14	10	0.3	0.5	0.6	0.4	0.4	0.3	1.2	2.0	9.3	7.6	3.2	1.5	9.8	9.8	9.8	10.7
	13	0.5	0.7	0.7	0.8	0.9	0.6	1.3	2.1	11.9	9.5	4.4	2.1	14.7	11.7	11.5	12.5
16	4	0.3	0.3	0.2	0.3	0.3	0.3	0.4	0.7	6.2	2.6	2.6	1.5	6.2	4.4	4.1	4.3
	7	0.4	0.5	0.4	0.5	0.5	0.4	0.8	1.2	10.0	4.4	3.2	1.8	10.9	6.6	7.4	7.3
	13	0.6	0.8	0.7	0.8	1.0	0.7	1.4	2.2	12.1	9.6	4.4	2.1	16.9	11.6	14.2	14.1
	17	0.2	0.5	0.4	0.6	0.4	0.3	1.5	2.2	10.7	8.6	6.0	1.3	19.6	13.1	20.8	16.7
18	7	0.4	0.6	0.4	0.6	0.6	0.5	0.9	1.4	9.4	4.2	3.3	1.9	10.0	6.6	7.1	7.1
	10	0.5	0.8	0.6	0.8	0.9	0.6	1.2	1.9	11.8	6.6	4.1	2.2	13.5	9.0	11.1	10.4
20	7	0.5	0.8	0.6	0.7	0.7	0.6	1.0	1.5	9.2	3.9	2.9	1.6	8.7	6.2	7.5	7.0
	10	0.7	1.0	0.8	0.8	1.0	0.7	1.5	2.1	10.7	5.9	3.5	1.8	12.4	8.9	12.3	10.2

Table 5

Wave Heights for Existing Conditions with Authorized Channel Depths
for Test Waves from 235 deg

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
swl = 0.0 ft																	
8	4	0.1	0.3	0.4	0.3	0.2	0.1	0.7	1.1	6.2	2.7	1.2	0.3	4.9	4.9	4.5	4.4
	10	0.3	0.5	0.5	0.4	0.4	0.3	0.8	1.6	8.6	6.5	2.3	0.8	9.3	8.3	9.6	9.9
10	4	0.1	0.2	0.3	0.3	0.2	0.1	0.5	0.9	7.4	2.6	1.2	0.4	6.3	4.5	4.7	4.2
	7	0.2	0.5	0.5	0.4	0.3	0.2	0.8	1.6	8.0	5.4	2.0	0.6	9.0	7.5	7.4	6.7
	10	0.4	0.6	0.5	0.6	0.7	0.3	0.9	1.7	9.2	7.3	3.0	0.9	10.9	8.7	10.5	10.3
	13	0.6	0.7	0.6	0.7	0.9	0.5	1.1	1.9	10.2	7.7	3.6	1.0	12.0	9.8	11.9	13.3
12	4	0.2	0.3	0.2	0.2	0.2	0.1	0.3	0.7	7.4	2.6	1.6	0.4	4.9	4.2	4.6	4.1
	7	0.4	0.5	0.5	0.4	0.6	0.3	0.8	1.5	8.7	6.5	2.5	0.8	7.6	6.6	8.3	7.0
	13	0.6	0.7	0.6	0.6	0.9	0.5	1.0	1.6	10.3	6.6	3.4	1.1	10.5	8.5	11.0	12.8
14	10	0.6	0.6	0.6	0.6	0.9	0.5	0.9	1.6	10.0	7.0	3.2	1.1	9.3	8.0	10.2	9.9
	13	0.7	0.7	0.7	0.7	1.0	0.6	1.0	1.7	10.1	6.6	3.4	1.0	10.2	8.4	11.3	12.8
16	4	0.2	0.3	0.2	0.3	0.4	0.2	0.4	0.6	7.9	3.0	1.8	0.6	6.0	4.0	5.1	4.1
	7	0.5	0.6	0.5	0.5	0.8	0.5	0.8	1.4	10.3	6.9	2.9	0.7	10.2	7.0	9.1	7.5
	13	0.6	0.7	0.7	0.7	1.0	0.6	1.0	1.9	10.7	7.4	3.6	1.2	12.6	9.3	11.7	12.9
	17	0.2	0.2	0.5	0.4	0.5	0.3	0.9	1.7	8.5	6.0	6.3	1.7	11.8	7.7	13.5	16.9
	20	0.1	0.1	0.3	0.3	0.4	0.2	0.6	1.0	12.9	7.4	5.2	1.4	13.1	8.2	10.2	18.4
18	7	0.6	0.6	0.5	0.6	0.7	0.5	0.8	1.2	11.4	5.8	2.7	0.8	10.1	6.2	7.7	7.2
	10	0.6	0.7	0.5	0.6	0.8	0.5	0.9	1.4	11.1	7.5	3.2	1.0	10.9	7.7	9.4	9.5
20	7	0.6	0.7	0.5	0.6	0.7	0.5	0.8	1.2	8.8	6.8	2.5	0.8	10.2	6.9	8.1	7.4
	10	0.7	0.8	0.6	0.7	0.9	0.6	1.1	1.6	9.0	8.0	2.6	0.8	11.2	8.2	10.3	9.8

(Continued)

Table 5 (Concluded)

Test Wave		Wave Height, ft, Gage Number															
Period	Height	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
sec	ft																
		swl = +5.4 ft															
8	4	0.2	0.3	0.4	0.3	0.2	0.1	0.8	1.1	5.2	2.8	1.6	0.8	4.2	4.4	4.2	4.1
	10	0.4	0.7	1.0	0.6	0.5	0.3	1.6	2.8	12.5	10.3	3.4	1.3	12.3	10.2	10.7	10.7
10	4	0.1	0.2	0.3	0.3	0.2	0.1	0.6	1.0	5.5	2.6	2.0	1.0	4.5	4.5	4.5	4.1
	7	0.2	0.4	0.6	0.4	0.3	0.2	1.0	1.9	9.8	7.3	2.8	1.3	7.3	7.8	8.1	7.6
	10	0.4	0.6	0.8	0.6	0.6	0.3	1.4	2.8	11.2	8.9	3.8	1.6	10.0	10.5	11.9	10.4
	13	0.5	0.7	0.9	0.8	1.0	0.5	1.4	2.8	12.1	10.5	4.6	1.9	11.7	11.8	14.0	13.5
12	4	0.2	0.3	0.3	0.2	0.2	0.2	0.5	1.0	5.5	2.7	2.2	1.0	3.8	4.0	4.5	4.0
	7	0.3	0.5	0.5	0.4	0.4	0.2	0.8	1.7	9.5	6.0	3.0	1.3	6.9	6.9	7.7	6.8
	13	0.6	0.9	0.8	0.7	0.8	0.5	1.4	2.4	11.8	10.6	4.6	1.8	11.5	11.3	12.5	13.3
14	10	0.6	0.8	0.9	0.9	1.0	0.6	1.4	2.6	12.2	8.2	4.4	2.1	11.9	10.5	11.7	10.3
	13	0.8	1.1	1.0	1.0	1.2	0.6	1.6	2.7	11.4	9.7	4.9	2.1	13.3	12.0	12.7	12.9
16	4	0.5	0.4	0.4	0.4	0.4	0.3	0.5	1.1	6.5	2.8	2.8	1.3	5.6	4.6	4.8	4.3
	7	0.8	0.7	0.6	0.6	0.8	0.5	0.9	1.8	10.3	7.4	3.9	1.8	10.7	8.0	9.0	7.4
	13	0.7	0.9	1.1	1.1	1.2	0.7	1.6	2.9	13.3	10.9	4.9	2.3	15.1	12.2	14.3	12.9
	17	0.4	0.4	0.6	0.6	0.7	0.5	1.2	2.5	10.4	10.3	9.3	1.6	25.0	9.3	16.3	16.8
	20	0.4	0.4	0.5	0.6	0.7	0.5	1.0	2.0	10.8	11.1	9.3	1.8	32.4	9.4	17.2	19.6
18	7	0.6	0.7	0.7	0.7	0.7	0.5	1.0	1.8	10.1	5.1	4.1	1.6	10.9	7.1	7.5	7.1
	10	0.7	1.0	0.9	0.9	1.1	0.8	1.3	2.4	12.0	7.8	4.1	2.0	12.1	9.6	10.1	9.6
20	7	0.7	0.9	0.9	0.8	0.9	0.6	1.1	1.9	9.3	5.7	3.7	1.6	10.9	7.0	7.8	6.9
	10	0.9	1.2	1.1	0.9	1.1	0.8	1.5	2.6	12.2	8.7	4.6	1.9	12.9	9.1	11.0	10.2

Table 6

Wave Heights for Existing Conditions with Authorized Channel Depths
for Test Waves from 210 deg

Test Wave		Wave Height, ft., Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.2	0.2	0.3	0.2	0.2	0.1	0.6	1.0	4.4	4.0	1.0	0.4	4.0	3.8	3.7	3.9
	10	0.2	0.5	0.5	0.4	0.5	0.3	0.9	1.7	7.3	5.9	2.9	0.8	8.2	10.5	10.2	10.1
10	4	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.4	5.3	4.5	1.3	0.4	4.5	4.3	3.7	3.8
	7	0.1	0.4	0.2	0.2	0.4	0.1	0.5	1.0	7.4	6.2	1.9	0.6	7.4	7.8	6.7	7.1
	10	0.3	0.6	0.6	0.5	0.8	0.4	1.1	2.2	8.0	6.2	3.1	0.9	7.6	10.7	10.4	10.0
	13	0.6	0.6	0.7	0.8	1.0	0.6	1.1	1.9	8.8	7.8	4.7	1.2	8.7	10.8	11.3	12.5
12	4	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.6	5.8	5.3	1.7	0.5	3.9	4.1	4.1	3.9
	7	0.2	0.4	0.3	0.3	0.4	0.3	0.5	1.0	8.4	6.4	2.3	0.7	6.5	6.7	6.8	6.7
	13	0.5	0.7	0.7	0.7	1.0	0.6	1.1	2.0	8.7	6.8	4.0	1.1	9.2	10.5	13.1	13.0
14	10	0.6	0.7	0.7	0.7	1.0	0.6	1.0	2.2	9.1	7.4	3.3	1.0	10.4	9.7	10.1	9.6
	13	0.7	0.7	0.7	0.8	1.1	0.8	1.2	2.0	8.3	7.0	3.9	1.1	10.1	12.4	12.1	13.4
16	4	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.3	6.8	5.5	1.6	0.5	5.0	4.4	3.7	4.3
	7	0.4	0.6	0.5	0.6	0.8	0.6	0.8	0.9	8.4	7.3	2.5	0.9	8.9	7.3	5.7	7.0
	13	0.5	0.7	0.6	0.7	1.1	0.7	1.1	2.1	8.9	7.7	3.8	1.1	11.0	12.6	11.6	12.9
	17	0.2	0.2	0.5	0.3	0.4	0.3	0.9	1.7	7.0	9.0	4.7	1.6	11.8	11.1	12.5	17.7
18	20	0.2	0.2	0.5	0.4	0.4	0.3	0.7	1.4	6.2	8.0	4.9	1.3	12.4	11.8	12.3	20.4
	7	0.4	0.5	0.3	0.5	0.5	0.4	0.6	0.8	9.7	7.7	2.5	0.7	8.9	7.3	5.8	7.0
20	10	0.6	0.7	0.6	0.7	0.9	0.6	0.9	1.6	9.8	7.5	2.8	1.0	11.0	10.7	9.2	10.6
	7	0.6	0.6	0.6	0.7	0.7	0.5	0.8	1.1	9.9	7.3	2.7	0.8	9.7	7.2	6.6	7.0
20	10	0.7	0.8	0.7	0.8	1.0	0.7	1.2	1.8	10.6	7.4	3.1	1.1	10.8	10.0	10.9	9.8

(Continued)

Table 6 (Concluded)

Test Wave		Wave Height, ft, Gage Number															
Period	Height	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
sec	ft																
		swl = +5.4 ft															
8	4	0.1	0.2	0.4	0.2	0.2	0.1	0.8	1.4	5.5	4.7	2.2	0.8	5.0	4.8	4.6	4.3
	10	0.2	0.6	0.6	0.5	0.5	0.2	1.2	2.0	11.3	8.4	4.0	1.4	11.1	11.3	9.7	10.7
10	4	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.8	6.0	5.3	2.8	1.1	4.5	5.4	4.8	4.3
	7	0.2	0.4	0.4	0.3	0.3	0.2	0.6	1.4	10.0	8.8	3.9	1.3	7.7	9.0	7.7	7.4
	10	0.3	0.5	0.6	0.5	0.6	0.3	1.1	2.1	12.2	9.6	4.5	1.7	10.3	11.9	10.4	10.5
	13	0.5	0.9	1.0	0.8	1.1	0.7	1.6	2.9	13.1	10.2	5.7	2.0	11.1	15.2	12.9	13.6
12	4	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.8	5.7	5.1	3.1	1.0	3.7	4.6	4.4	4.4
	7	0.4	0.8	0.8	0.6	0.8	0.7	0.9	1.4	9.8	9.2	4.7	1.5	7.7	7.9	7.2	7.3
	13	0.4	0.8	0.7	0.7	0.9	0.6	1.5	2.6	13.0	10.6	5.4	2.0	12.4	13.7	12.5	12.4
14	10	0.2	0.6	0.5	0.5	0.6	0.3	1.1	1.9	11.0	9.8	4.4	1.6	10.3	11.5	10.1	10.6
	13	0.7	0.9	0.9	1.1	1.4	0.7	1.6	2.8	13.8	10.7	5.9	2.2	15.1	14.6	12.3	13.6
16	4	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.7	7.0	5.1	2.7	1.2	5.5	4.5	3.8	4.0
	7	0.4	0.5	0.4	0.6	0.6	0.4	0.7	1.4	11.1	9.5	4.6	1.7	11.5	8.6	7.2	7.4
	13	0.7	1.1	1.0	1.0	1.3	0.9	1.7	3.0	12.9	11.3	5.7	2.0	15.7	15.2	12.6	13.8
	17	0.2	0.4	0.5	0.5	0.6	0.3	1.4	2.1	12.9	14.7	9.3	3.5	16.0	13.6	15.5	17.1
	20	0.1	0.4	0.7	0.5	0.4	0.3	1.3	1.9	16.4	15.4	8.2	3.5	18.1	13.0	14.1	19.7
18	7	0.6	0.6	0.5	0.6	0.6	0.6	0.8	1.3	10.8	8.2	4.7	1.8	10.2	7.2	6.4	6.9
	10	0.7	0.9	0.8	0.9	1.1	0.8	1.3	2.1	13.6	10.8	5.6	2.0	14.1	11.3	9.5	10.5
20	7	0.7	0.9	0.7	0.8	1.0	0.8	1.2	1.8	10.1	8.1	5.1	1.8	10.3	7.5	7.8	6.8
	10	0.7	1.1	0.8	1.0	1.2	0.8	1.4	2.2	13.8	10.7	5.3	1.9	12.3	9.8	9.5	10.0

Table 7

Comparison of Wave Heights in the Inner Harbor
for Existing Conditions (with Authorized
Entrance Channel Depths) for Various
Test Conditions
swl = +5.4 ft

Wave Form*	Test Wave			Wave Height, ft						
	Direction deg	Period sec	Height ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7
M	235	4	4	0.1	0.1	0.2	0.1	0.1	0.1	0.6
M	235	4	7	0.2	0.2	0.3	0.2	0.1	0.1	1.3
M	235	4	10	0.2	0.2	0.4	0.3	0.2	0.1	1.3
M	235	6	4	0.3	0.1	0.5	0.1	0.1	0.1	0.7
M	235	6	7	0.3	0.2	0.7	0.2	0.1	0.1	1.0
M	242	6	7	0.4	0.2	0.7	0.1	0.2	0.1	0.9
M	235	6	10	0.5	0.4	1.2	0.4	0.3	0.2	1.3
M	242	6	10	0.5	0.3	1.1	0.3	0.3	0.2	1.2
J	235	8	4	0.2	0.3	0.4	0.3	0.2	0.1	0.8
M	235	8	4	0.1	0.3	0.5	0.3	0.1	0.1	0.9
D	235	8	4	0.2	0.3	0.4	0.4	0.3	0.1	0.6
J	242	8	4	0.2	0.2	0.4	0.2	0.1	0.1	0.7
M	235	8	7	0.2	0.5	0.6	0.4	0.2	0.2	1.5
M	242	8	7	0.2	0.5	0.6	0.5	0.2	0.2	1.4
J	235	8	10	0.4	0.7	1.0	0.6	0.5	0.3	1.6
M	235	8	10	0.5	0.8	1.1	1.0	0.7	0.8	2.2
D	235	8	10	0.5	0.8	0.9	0.8	0.8	0.6	1.2
M	242	8	10	0.3	0.7	1.1	0.8	0.9	0.5	2.2
J	235	8	13	0.3	0.5	0.7	0.4	0.6	0.4	1.2
M	235	8	13	0.4	0.7	0.9	0.7	0.4	0.3	1.8
D	235	8	13	0.6	0.9	0.9	0.9	0.9	0.6	1.4
J	235	10	4	0.1	0.2	0.3	0.3	0.2	0.1	0.6
M	235	10	4	0.1	0.2	0.2	0.2	0.1	0.1	0.4

(Continued)

*NOTE: Discrete = D, JONSWAP = J, Monochromatic = M

Table 7 (Concluded)

Wave Form	Test Wave			Wave Height, ft						
	Direction deg	Period sec	Height ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7
J	235	10	7	0.2	0.4	0.6	0.4	0.3	0.2	1.0
M	235	10	7	0.2	0.5	0.4	0.3	0.2	0.2	1.5
J	235	10	10	0.4	0.6	0.8	0.6	0.6	0.3	1.4
M	235	10	10	0.2	0.6	0.6	0.5	0.2	0.2	1.5
J	235	10	13	0.5	0.7	0.9	0.8	1.0	0.5	1.4
M	235	10	13	0.2	0.7	0.5	0.5	0.2	0.2	1.0
J	235	14	10	0.6	0.8	0.9	0.9	1.0	0.6	1.4
M	235	14	10	0.5	0.4	0.7	0.5	0.4	0.4	1.2
J	235	16	13	0.7	0.9	1.1	1.1	1.2	0.7	1.6
M	235	16	13	0.5	0.5	0.7	0.8	0.8	0.6	1.5

Table 8

Wave Heights for Plan 1 for Test Waves
from 250 deg

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>swl = 0.0 ft</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.9	2.6	0.8	0.2	4.5	2.0	3.8	4.0
	10	0.1	0.3	0.2	0.2	0.2	0.1	0.4	0.6	8.9	6.4	1.3	0.4	7.9	4.1	7.7	9.5
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	5.0	2.5	0.8	0.3	4.7	2.2	4.0	4.1
	7	0.1	0.3	0.1	0.1	0.1	0.1	0.3	0.5	7.7	4.7	1.0	0.4	6.9	3.2	6.6	6.8
	10	0.1	0.3	0.2	0.2	0.2	0.1	0.3	0.5	10.4	6.2	1.4	0.4	8.1	4.1	8.6	9.3
	13	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.6	10.5	7.3	1.8	0.5	8.6	5.1	10.1	11.7
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	4.6	2.3	0.7	0.3	3.4	2.1	3.4	3.7
	7	0.1	0.3	0.1	0.1	0.1	0.1	0.2	0.4	7.6	4.3	1.0	0.4	6.3	3.1	5.9	6.2
	13	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.6	11.2	7.6	1.7	0.6	8.4	4.7	9.9	11.2
14	10	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.4	10.2	6.2	1.6	0.5	8.8	3.8	7.5	8.0
	13	0.2	0.3	0.2	0.3	0.3	0.3	0.4	0.6	11.7	7.1	2.0	0.6	9.7	5.0	9.4	11.1
16	4	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	5.1	2.2	1.2	0.3	4.9	2.3	3.9	3.8
	7	0.1	0.3	0.1	0.2	0.2	0.1	0.2	0.4	8.5	4.2	1.6	0.4	8.7	3.5	6.7	6.4
	13	0.2	0.4	0.2	0.3	0.4	0.2	0.4	0.6	11.7	7.2	2.1	0.7	11.2	4.9	10.9	11.5
	17	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.6	12.8	7.8	1.8	0.5	12.9	5.2	8.9	16.4
	20	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.6	10.1	8.2	1.8	0.6	12.3	6.0	9.2	18.9
18	7	0.2	0.2	0.1	0.2	0.1	0.1	0.3	0.3	7.2	3.7	1.4	0.5	7.9	2.8	5.7	5.6
	10	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.4	8.6	5.9	1.6	0.5	8.7	3.5	8.3	8.7
20	7	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.4	6.8	4.5	1.2	0.4	8.3	2.9	6.2	6.7
	10	0.2	0.4	0.2	0.2	0.3	0.2	0.3	0.5	8.8	6.1	1.6	0.6	9.1	4.1	8.7	10.1

(Continued)

Table 8 (Concluded)

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.5	4.7	2.6	1.1	0.6	4.9	2.5	4.0	4.0
	10	0.1	0.3	0.3	0.2	0.2	0.1	0.5	0.8	10.5	7.8	1.8	1.0	10.5	4.9	9.7	10.2
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.2	2.1	1.3	0.7	3.5	2.3	3.4	3.5
	7	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.6	7.6	4.1	1.7	1.0	6.2	3.8	6.4	6.4
	10	0.1	0.4	0.2	0.2	0.2	0.1	0.4	0.8	10.2	7.0	2.0	1.1	9.0	4.9	9.5	10.0
	13	0.2	0.3	0.3	0.3	0.4	0.2	0.5	0.9	12.5	8.8	2.3	1.2	10.6	6.0	11.2	11.9
12	4	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.4	4.4	2.1	1.1	0.9	3.6	2.3	3.3	3.3
	7	0.1	0.3	0.2	0.2	0.2	0.1	0.3	0.7	8.7	4.2	1.7	1.2	7.1	4.0	6.5	6.7
	13	0.2	0.4	0.3	0.3	0.5	0.3	0.5	1.0	13.1	8.7	2.5	1.4	11.5	5.9	10.9	12.0
14	10	0.1	0.3	0.2	0.2	0.2	0.1	0.4	0.8	10.7	6.9	2.0	1.1	9.1	5.2	9.2	9.6
	13	0.2	0.4	0.3	0.3	0.4	0.3	0.6	0.9	14.0	8.7	2.8	1.5	13.3	6.1	10.7	11.5
16	4	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.5	5.2	2.3	1.6	1.1	5.7	2.7	3.6	3.6
	7	0.3	0.3	0.2	0.3	0.3	0.2	0.4	0.7	9.1	4.8	2.1	1.5	10.7	4.1	7.1	6.9
	13	0.3	0.4	0.3	0.4	0.6	0.4	0.6	1.1	14.1	10.6	3.2	1.8	16.6	6.7	12.8	12.9
	17	0.1	0.3	0.2	0.3	0.2	0.2	0.7	1.0	15.9	10.7	3.0	1.1	19.5	6.4	13.7	17.6
	20	0.1	0.2	0.2	0.3	0.3	0.2	0.6	0.7	16.0	14.6	3.9	1.3	19.1	7.3	12.1	20.9
18	7	0.3	0.4	0.2	0.3	0.3	0.3	0.5	0.7	8.8	4.4	2.0	1.7	10.7	3.8	6.7	6.4
	10	0.4	0.4	0.3	0.4	0.5	0.3	0.6	0.9	11.7	6.6	2.4	1.8	13.4	5.0	9.6	9.1
20	7	0.4	0.5	0.3	0.4	0.4	0.4	0.6	0.7	8.3	4.3	2.2	1.4	8.8	4.3	6.7	6.5
	10	0.4	0.5	0.4	0.5	0.6	0.4	0.7	1.0	11.6	7.1	2.6	1.5	12.2	6.1	10.0	9.8

Table 9

Wave Heights for Plan 1 for Test Waves
from 235 deg

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.4	5.6	3.4	0.9	0.3	5.9	3.0	5.2	5.0
	10	0.1	0.3	0.2	0.2	0.2	0.2	0.3	0.6	9.4	6.4	2.0	0.5	9.1	4.3	9.4	10.6
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	4.8	2.1	1.0	0.3	5.4	2.5	4.2	4.1
	7	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.5	6.9	5.0	1.5	0.4	8.4	3.6	7.0	6.8
	10	0.1	0.4	0.2	0.2	0.2	0.2	0.3	0.5	9.2	6.4	1.8	0.5	8.6	4.4	9.9	9.2
	13	0.2	0.5	0.2	0.2	0.3	0.2	0.4	0.6	10.2	6.7	2.3	0.7	9.0	5.4	10.5	11.6
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	3.8	2.2	1.0	0.3	3.8	2.7	4.2	3.4
	7	0.1	0.4	0.2	0.2	0.2	0.2	0.3	0.5	7.5	6.0	1.7	0.6	7.3	4.2	8.1	6.9
	13	0.2	0.4	0.3	0.3	0.4	0.3	0.4	0.7	10.8	6.6	2.4	0.7	9.9	6.0	10.6	12.8
14	10	0.2	0.3	0.2	0.3	0.3	0.2	0.4	0.6	9.6	6.8	2.3	0.7	9.2	4.8	9.7	9.2
	13	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.7	10.4	6.5	2.3	0.7	9.4	5.7	10.6	11.8
16	4	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.3	4.7	2.3	1.1	0.3	5.7	2.9	4.6	3.6
	7	0.2	0.4	0.2	0.3	0.3	0.2	0.3	0.5	8.1	5.7	1.7	0.5	9.5	4.6	8.1	6.6
	13	0.2	0.4	0.3	0.3	0.4	0.3	0.4	0.6	10.8	6.7	2.2	0.8	10.8	6.1	10.8	11.6
	17	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.5	12.6	5.6	3.7	1.0	12.0	5.4	13.8	16.7
	20	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.5	10.3	7.0	3.5	0.9	13.2	5.3	10.4	16.8
18	7	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.4	7.0	4.2	1.5	0.5	8.5	3.3	6.5	6.0
	10	0.3	0.4	0.2	0.3	0.3	0.2	0.4	0.6	9.2	6.2	2.0	0.7	10.3	4.4	9.3	8.7
20	7	0.2	0.4	0.3	0.3	0.3	0.2	0.4	0.5	8.2	5.6	1.8	0.6	9.2	3.9	7.7	7.2
	10	0.2	0.4	0.3	0.4	0.4	0.3	0.4	0.7	10.1	6.8	2.2	0.7	10.0	4.7	9.3	9.7

(Continued)

Table 9 (Concluded)

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>swl = +5.4 ft</u>																	
8	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.5	5.1	3.0	1.0	0.6	3.8	2.5	4.0	3.9
	10	0.1	0.3	0.3	0.2	0.2	0.1	0.5	0.8	11.2	9.8	2.5	1.0	9.0	5.3	10.0	10.6
10	4	0.1	0.2	0.3	0.2	0.1	0.1	0.3	0.5	5.0	3.0	1.7	0.9	3.7	3.2	4.4	4.0
	7	0.1	0.2	0.3	0.2	0.2	0.1	0.4	0.9	8.4	6.4	2.3	1.1	5.9	4.8	7.3	6.8
	10	0.2	0.3	0.3	0.3	0.3	0.2	0.5	1.0	10.9	9.0	2.8	1.2	8.1	5.8	10.3	9.4
	13	0.2	0.4	0.4	0.4	0.5	0.3	0.6	1.1	15.0	11.8	3.7	1.5	10.3	7.0	13.0	13.4
12	4	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.5	5.2	3.0	2.0	0.9	3.4	2.8	4.1	3.6
	7	0.2	0.2	0.3	0.3	0.3	0.2	0.4	0.9	9.6	8.1	3.0	1.3	7.2	5.3	8.2	7.0
	13	0.3	0.5	0.4	0.4	0.6	0.3	0.6	1.2	17.9	12.5	4.2	1.7	12.5	7.3	13.5	13.5
14	10	0.3	0.5	0.4	0.4	0.6	0.3	0.6	1.0	13.5	10.3	3.4	1.7	12.2	6.2	11.0	9.1
	13	0.4	0.5	0.6	0.5	0.7	0.4	0.8	1.2	18.8	12.8	4.0	1.9	15.4	7.8	13.9	13.6
16	4	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.8	6.8	3.6	2.0	1.2	6.8	3.7	4.9	4.2
	7	0.3	0.4	0.3	0.4	0.5	0.3	0.5	1.1	11.8	9.7	2.8	1.6	11.7	5.6	8.8	7.6
	13	0.4	0.5	0.5	0.6	0.7	0.4	0.7	1.3	19.5	13.4	4.1	1.9	15.4	7.6	14.3	12.6
	17	0.2	0.2	0.2	0.2	0.3	0.2	0.4	1.0	25.2	10.9	4.9	1.0	18.5	5.9	12.5	14.0
	20	0.2	0.2	0.2	0.3	0.4	0.3	0.4	1.1	20.6	11.3	5.4	1.2	17.0	7.4	14.4	15.5
18	7	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.9	11.9	7.0	3.3	1.8	11.0	4.9	7.7	6.9
	10	0.4	0.5	0.5	0.6	0.7	0.6	0.7	1.1	17.2	10.7	4.0	2.0	13.6	6.2	10.6	9.8
20	7	0.4	0.4	0.4	0.4	0.5	0.4	0.5	1.0	10.6	8.2	3.3	1.5	10.4	5.1	8.5	6.8
	10	0.4	0.5	0.5	0.5	0.6	0.4	0.6	1.2	14.4	10.4	3.6	1.7	12.0	6.4	11.0	9.0

Table 10

Wave Heights for Plan 1 for Test Waves
from 210 deg

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	4.1	4.3	1.2	0.3	4.3	3.2	3.8	3.7
	10	0.2	0.4	0.3	0.2	0.4	0.2	0.5	0.9	9.7	6.9	2.8	0.6	9.3	7.5	10.4	10.3
10	4	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.5	4.5	4.8	1.5	0.3	4.9	3.5	3.9	3.9
	7	0.1	0.4	0.2	0.2	0.2	0.2	0.4	0.8	7.9	6.7	1.9	0.5	7.7	6.5	6.7	7.0
	10	0.2	0.4	0.3	0.3	0.4	0.3	0.5	1.0	10.8	7.3	2.8	0.7	8.7	8.7	9.8	10.1
	13	0.4	0.5	0.4	0.5	0.7	0.4	0.7	1.2	11.7	8.1	4.5	1.0	9.8	9.3	12.0	13.2
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	4.8	5.6	1.9	0.4	3.8	3.6	4.2	4.2
	7	0.1	0.3	0.2	0.2	0.2	0.2	0.3	0.7	7.6	6.7	2.5	0.6	6.8	5.9	6.5	6.6
	13	0.2	0.5	0.3	0.3	0.4	0.3	0.5	0.9	10.6	6.6	3.4	0.9	8.8	7.7	11.7	12.7
14	10	0.2	0.4	0.3	0.3	0.4	0.3	0.5	0.8	9.5	7.2	2.6	0.7	10.3	7.8	9.9	9.4
	13	0.3	0.4	0.4	0.5	0.6	0.5	0.6	0.9	10.4	6.6	3.2	0.9	10.0	7.9	12.3	12.3
16	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	4.9	5.8	1.4	0.4	5.0	3.3	3.7	4.2
	7	0.2	0.4	0.2	0.2	0.3	0.2	0.3	0.5	9.9	7.3	2.2	0.6	10.3	5.8	7.3	7.4
	13	0.3	0.5	0.3	0.4	0.5	0.4	0.6	0.9	11.0	7.7	4.1	0.9	11.0	8.4	11.1	12.8
	17	0.1	0.1	0.2	0.2	0.2	0.4	0.4	0.6	15.0	9.5	3.2	0.9	12.5	6.6	11.2	15.6
	20	0.1	0.1	0.2	0.2	0.2	0.2	0.5	0.7	12.9	8.2	5.8	1.0	11.3	9.0	10.2	17.1
18	7	0.2	0.4	0.2	0.3	0.3	0.2	0.3	0.4	6.6	6.2	2.3	0.6	8.1	4.5	5.0	5.4
	10	0.3	0.4	0.2	0.4	0.4	0.4	0.5	0.8	9.9	6.9	3.6	0.8	10.1	6.7	9.3	8.4
20	7	0.2	0.3	0.2	0.3	0.4	0.3	0.4	0.6	6.2	5.9	2.8	0.5	8.1	4.1	5.6	5.5
	10	0.4	0.4	0.3	0.4	0.4	0.3	0.5	0.8	8.1	7.1	3.3	0.8	9.9	5.6	8.4	7.8

(Continued)

Table 10 (Concluded)

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.6	5.4	5.0	2.0	0.6	6.0	4.4	4.3	4.8
	10	0.2	0.6	0.4	0.3	0.5	0.1	0.8	1.3	12.6	9.9	3.5	1.3	13.0	9.9	10.6	11.9
10	4	0.1	0.2	0.2	0.1	0.1	0.1	0.4	0.7	6.4	6.2	2.6	1.0	5.7	5.1	5.1	5.3
	7	0.1	0.3	0.3	0.2	0.2	0.1	0.5	1.1	8.8	10.2	3.6	1.4	9.2	8.2	8.3	8.7
	10	0.2	0.6	0.4	0.3	0.4	0.2	0.7	1.4	14.1	11.0	3.9	1.7	12.1	10.0	12.0	12.3
	13	0.4	0.9	0.6	0.5	0.7	0.2	1.0	1.6	15.7	12.1	4.6	1.9	13.7	11.9	15.4	16.0
12	4	0.1	0.2	0.1	0.1	0.1	0.4	0.2	0.5	3.8	5.1	2.3	0.9	3.9	3.6	3.9	4.0
	7	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.8	6.4	9.3	3.6	1.3	8.1	6.7	7.2	7.1
	13	0.3	0.5	0.4	0.4	0.6	0.4	0.8	1.3	11.0	10.9	4.3	1.6	13.2	9.5	13.8	12.0
14	10	0.2	0.4	0.3	0.3	0.4	0.2	0.6	1.2	9.4	10.0	3.4	1.5	10.4	9.6	9.7	10.1
	13	0.4	0.6	0.5	0.6	0.8	0.5	0.9	1.4	11.8	11.9	4.5	1.7	15.7	11.3	12.6	13.1
16	4	0.2	0.4	0.3	0.4	0.4	0.3	0.4	0.6	5.2	5.3	2.5	1.1	5.5	3.9	3.7	4.4
	7	0.3	0.4	0.2	0.4	0.3	0.3	0.5	0.8	8.3	10.3	3.9	1.6	11.7	6.9	7.4	8.1
	13	0.4	0.6	0.5	0.6	0.7	0.5	0.8	1.3	13.3	11.4	4.9	2.0	15.6	11.2	13.3	13.5
	17	0.1	0.4	0.3	0.4	0.3	0.3	1.0	1.3	16.8	13.2	10.0	3.0	19.0	12.1	14.5	20.6
	20	0.2	0.3	0.3	0.4	0.3	0.3	0.9	1.4	16.0	12.3	8.5	2.6	19.2	12.5	14.7	22.3
18	7	0.3	0.4	0.3	0.4	0.4	0.4	0.6	0.7	8.4	7.8	3.8	1.4	9.8	5.4	6.1	6.6
	10	0.4	0.6	0.5	0.5	0.7	0.4	0.7	0.9	12.3	10.1	5.0	1.7	13.5	8.3	9.1	10.1
20	7	0.3	0.6	0.4	0.5	0.5	0.5	0.7	0.9	8.5	7.9	4.1	1.5	10.1	6.0	7.4	6.8
	10	0.4	0.7	0.4	0.6	0.7	0.5	0.9	1.2	11.5	10.2	5.2	1.6	12.6	7.6	9.6	9.4

Table 11

Wave Heights for Plans 2-7 for Test Waves
from 235 deg; swl = +5.4 ft

<u>Test Wave</u>		<u>Wave Height, ft, Gage Number</u>															
<u>Period</u>	<u>Height</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
<u>sec</u>	<u>ft</u>																
<u>Plan 2</u>																	
8	4	0.1	0.1	0.1	0.2	0.1	0.1	0.3	0.4	4.9	2.3	0.6	0.5	4.0	2.6	3.9	3.6
14	10	0.2	0.4	0.3	0.4	0.5	0.3	0.5	0.8	12.2	7.8	3.0	1.3	12.9	6.6	11.2	9.3
16	13	0.3	0.4	0.3	0.5	0.5	0.3	0.6	1.0	16.0	10.8	3.5	1.5	17.1	7.1	13.3	11.7
<u>Plan 3</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	5.4	2.7	0.7	0.6	4.5	2.5	3.9	3.7
14	10	0.1	0.3	0.2	0.3	0.5	0.2	0.6	0.8	13.9	9.1	3.5	1.4	14.7	6.2	10.9	9.3
16	13	0.2	0.4	0.3	0.4	0.5	0.2	0.7	0.9	16.9	12.2	3.9	1.6	18.2	6.6	13.5	11.4
<u>Plan 4</u>																	
8	4	0.1	0.2	0.1	0.2	0.1	0.1	0.3	0.2	5.6	2.5	0.7	0.6	4.5	2.2	4.0	3.6
14	10	0.1	0.4	0.2	0.3	0.4	0.2	0.5	0.7	14.0	9.3	3.1	1.3	14.8	5.9	11.2	9.2
16	13	0.2	0.3	0.3	0.4	0.4	0.3	0.7	0.8	17.4	13.1	3.8	1.6	18.9	6.1	13.4	11.5
<u>Plan 5</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	3.9	2.3	0.5	0.5	4.0	2.0	4.0	3.5
14	10	0.1	0.3	0.2	0.2	0.4	0.2	0.4	0.6	12.0	7.7	2.4	1.2	12.6	5.9	11.6	8.7
16	13	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.7	15.3	11.5	3.0	1.3	16.2	5.9	12.6	10.6
<u>Plan 6</u>																	
8	4	0.1	0.1	0.1	0.2	0.1	0.1	0.3	0.3	5.4	3.0	0.7	0.5	4.2	2.4	4.1	3.9
14	10	0.2	0.3	0.3	0.3	0.5	0.3	0.4	0.8	12.2	8.3	2.7	1.2	12.7	6.1	11.3	9.4
16	13	0.3	0.4	0.3	0.4	0.6	0.3	0.5	0.9	16.3	11.0	3.0	1.4	16.3	6.7	13.7	11.9
<u>Plan 7</u>																	
8	4	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.3	4.6	2.4	0.6	0.4	3.8	2.0	4.1	3.6
14	10	0.2	0.3	0.2	0.3	0.4	0.2	0.4	0.7	13.1	7.8	2.5	1.2	13.2	5.9	10.9	9.6
16	13	0.2	0.4	0.3	0.4	0.5	0.3	0.5	0.9	16.0	11.4	3.0	1.4	16.4	6.4	13.1	11.5

Table 12

Wave Heights for Plans 8-13 for Test Waves
from 235 deg; swl = +5.4 ft

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<u>Plan 8</u>																	
8	4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.4	3.8	2.5	0.7	0.6	4.1	2.4	4.1	3.7
14	10	0.2	0.4	0.3	0.3	0.5	0.2	0.5	0.8	9.8	8.0	2.9	1.4	13.2	5.7	10.9	9.0
16	13	0.3	0.4	0.3	0.3	0.6	0.3	0.6	1.0	12.5	10.8	3.3	1.5	16.7	6.6	13.7	11.3
<u>Plan 9</u>																	
8	4	0.1	0.1	0.2	0.1	0.1	0.1	0.4	0.4	4.3	2.4	0.7	0.6	4.1	2.7	4.1	3.7
14	10	0.2	0.4	0.3	0.3	0.4	0.2	0.5	0.8	11.0	8.2	2.9	1.4	13.2	6.5	10.9	9.0
16	13	0.3	0.4	0.3	0.4	0.5	0.3	0.6	1.0	14.2	10.7	3.4	1.6	17.1	7.2	13.6	11.3
<u>Plan 10</u>																	
8	4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.3	4.5	2.5	0.6	0.6	4.1	2.5	4.1	3.7
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.4	0.8	11.5	8.3	2.9	1.3	13.8	6.3	11.1	9.3
16	13	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.9	15.2	11.6	3.5	1.5	17.8	6.9	13.7	11.4
<u>Plan 11</u>																	
8	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.4	4.8	2.9	0.9	0.7	4.3	2.8	4.2	3.9
14	10	0.3	0.5	0.4	0.3	0.6	0.3	0.6	0.9	11.4	8.0	2.9	1.6	13.6	6.4	11.1	9.3
16	13	0.3	0.5	0.4	0.5	0.8	0.4	0.8	1.1	14.5	10.9	3.4	1.7	17.3	7.4	13.6	11.5
<u>Plan 12</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	3.9	2.6	1.0	0.7	4.3	2.4	3.8	3.6
14	10	0.3	0.6	0.4	0.5	0.8	0.4	0.9	1.3	10.7	8.8	3.2	1.7	14.2	5.3	10.8	8.7
16	13	0.5	0.7	0.5	0.7	1.4	0.5	1.1	1.7	13.4	12.8	4.0	1.9	18.6	6.3	13.4	11.1
<u>Plan 13</u>																	
8	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.4	4.1	2.9	1.0	0.7	4.8	2.0	4.2	3.8
14	10	0.4	0.6	0.5	0.5	0.8	0.4	0.9	1.3	12.0	9.7	3.3	1.8	15.4	5.4	11.5	9.4
16	13	0.5	0.7	0.5	0.7	1.0	0.6	1.1	1.7	14.1	13.2	3.8	2.0	19.4	6.0	13.5	11.7

Table 13

Wave Heights for Plans 14-18 for Test Waves
from 235 deg; swl = +5.4 ft

<u>Test Wave</u>		<u>Wave Height, ft, Gage Number</u>															
<u>Period</u>	<u>Height</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
<u>sec</u>	<u>ft</u>																
<u>Plan 14</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	4.0	2.6	0.7	0.5	3.8	2.5	4.1	3.6
14	10	0.1	0.4	0.2	0.3	0.4	0.2	0.5	0.9	10.8	7.7	2.7	1.4	11.8	5.5	10.5	8.5
16	13	0.2	0.4	0.3	0.4	0.5	0.2	0.6	1.0	13.2	10.1	3.4	1.6	15.1	6.5	12.7	10.8
<u>Plan 15</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	4.1	2.5	0.8	0.5	4.0	2.6	3.9	3.7
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.8	11.0	7.9	2.8	1.4	12.6	5.6	10.4	8.8
16	13	0.2	0.4	0.2	0.3	0.5	0.2	0.6	1.0	13.2	10.2	3.4	1.6	15.5	6.6	12.7	10.9
<u>Plan 16</u>																	
8	4	0.1	0.1	0.1	0.1	0.3	0.1	0.3	0.3	4.2	2.6	0.9	0.5	4.0	3.0	4.0	3.7
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.8	10.7	7.7	3.0	1.4	12.3	5.9	10.4	8.9
16	13	0.2	0.4	0.3	0.3	0.5	0.2	0.6	1.0	13.0	10.5	3.5	1.7	14.7	7.2	12.4	11.1
<u>Plan 17</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	4.2	2.4	0.9	0.5	4.0	2.9	3.9	3.7
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.9	11.6	8.2	3.2	1.5	12.5	6.0	10.6	8.9
16	13	0.3	0.4	0.3	0.4	0.5	0.2	0.6	1.1	14.2	11.0	3.8	1.8	15.9	7.6	13.1	11.0
<u>Plan 18</u>																	
8	4	0.1	0.3	0.2	0.1	0.1	0.1	0.4	0.6	4.6	3.9	1.1	0.6	4.3	3.2	4.1	3.8
14	10	0.2	0.5	0.3	0.4	0.6	0.4	0.6	1.1	12.2	8.8	3.5	1.7	13.2	7.0	11.2	9.1
16	13	0.3	0.5	0.4	0.5	0.8	0.4	0.7	1.3	15.0	11.4	4.1	2.0	15.3	8.1	13.4	11.4

Table 14

Wave Heights for Plans 19-22 for Test Waves
from 235 deg; swl = +5.4 ft

<u>Test Wave</u>		<u>Wave Height, ft. Gage Number</u>															
<u>Period</u>	<u>Height</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
<u>sec</u>	<u>ft</u>																
<u>Plan 19</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	4.4	2.5	1.0	0.6	4.1	3.0	4.1	3.8
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.9	11.2	8.3	3.3	1.5	12.7	6.1	10.8	9.1
16	13	0.3	0.4	0.3	0.4	0.5	0.3	0.6	1.1	13.6	11.2	3.8	1.7	15.4	7.2	13.1	11.0
<u>Plan 20</u>																	
8	4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.4	4.3	2.5	1.0	0.6	4.1	3.1	4.0	3.8
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.9	11.0	8.2	3.1	1.4	12.8	6.2	10.6	9.0
16	13	0.3	0.4	0.3	0.4	0.5	0.2	0.6	1.0	14.1	11.0	3.8	1.6	15.5	7.5	12.8	11.4
<u>Plan 21</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	4.6	2.7	1.0	0.6	4.2	3.3	4.1	3.9
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.4	0.8	11.8	8.2	3.5	1.5	13.3	6.5	11.3	9.4
16	13	0.3	0.4	0.3	0.3	0.5	0.2	0.5	0.9	14.9	11.6	4.0	1.7	16.3	8.0	13.3	11.7
<u>Plan 22</u>																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	4.6	2.7	1.0	0.7	4.4	3.1	4.3	4.0
14	10	0.2	0.3	0.2	0.2	0.4	0.2	0.4	0.8	12.4	8.6	3.4	1.5	13.3	6.2	11.5	9.5
16	13	0.2	0.4	0.3	0.3	0.5	0.2	0.5	0.9	15.1	11.3	3.9	1.7	16.7	7.6	13.5	11.7

Table 15

Wave Heights for Plan 17 for Test Waves
from 250 deg

Test Wave		Wave Height, ft., Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	4.5	2.3	0.7	0.2	4.1	1.9	3.7	4.1
	10	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.5	9.1	5.7	1.3	0.3	7.9	4.0	7.5	10.0
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	4.7	2.3	0.7	0.2	4.4	2.2	3.8	4.1
	7	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.4	8.0	4.8	1.1	0.3	6.6	3.1	6.4	7.1
	10	0.1	0.3	0.1	0.1	0.1	0.1	0.3	0.5	10.0	5.6	1.4	0.4	7.8	3.8	8.4	9.3
	13	0.1	0.3	0.2	0.2	0.2	0.1	0.3	0.6	10.3	6.3	1.8	0.5	8.3	4.6	9.6	11.4
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	3.9	2.1	0.6	0.3	3.4	2.0	3.3	3.6
	7	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	6.9	4.3	1.0	0.4	6.2	2.9	5.9	6.5
	13	0.1	0.4	0.1	0.2	0.2	0.2	0.3	0.6	10.4	6.7	1.9	0.7	8.6	4.8	10.1	12.7
14	10	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.4	9.3	5.5	1.5	0.4	8.7	3.5	7.9	9.5
	13	0.2	0.3	0.1	0.2	0.2	0.2	0.3	0.6	10.7	6.7	1.8	0.6	9.8	4.5	10.0	13.7
16	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	4.6	2.2	1.0	0.3	5.0	2.1	3.9	4.6
	7	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.3	7.9	4.1	1.4	0.4	8.6	3.3	6.4	7.9
	13	0.2	0.4	0.2	0.2	0.3	0.2	0.3	0.6	11.3	6.8	2.0	0.7	11.1	4.8	10.5	14.0
	17	0.1	0.1	0.2	0.2	0.2	0.1	0.3	0.6	10.0	5.5	1.6	0.5	13.7	5.8	10.4	14.5
	20	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.5	10.5	5.7	1.6	0.5	11.9	5.0	11.0	15.7
18	7	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.3	7.0	3.7	1.1	0.5	7.7	2.9	5.3	7.5
	10	0.2	0.4	0.1	0.2	0.2	0.1	0.3	0.4	10.5	5.7	1.6	0.6	9.1	3.6	7.6	10.4
20	7	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.3	8.0	4.3	1.0	0.5	8.2	2.6	5.4	8.0
	10	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.4	10.6	6.0	1.6	0.6	9.1	3.4	7.5	10.7

(Continued)

Table 15 (Concluded)

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.1	0.2	0.1	0.1	0.1	0.3	0.5	4.5	2.6	1.1	0.6	4.7	2.3	3.9	4.3
	10	0.1	0.4	0.3	0.2	0.2	0.1	0.5	0.8	10.2	7.2	2.0	1.0	10.1	5.0	9.6	10.4
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.2	2.2	1.2	0.8	3.4	2.3	3.4	3.5
	7	0.1	0.2	0.2	0.1	0.1	0.1	0.4	0.6	7.2	3.7	1.7	1.1	5.8	3.6	6.0	6.2
	10	0.1	0.4	0.3	0.2	0.2	0.1	0.5	0.9	11.2	7.3	2.1	1.2	8.9	5.1	9.1	10.0
	13	0.2	0.4	0.3	0.3	0.3	0.2	0.6	1.0	13.4	8.2	2.4	1.4	10.6	6.2	10.9	11.8
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.3	2.2	1.1	1.0	3.4	2.2	3.3	3.6
	7	0.1	0.2	0.2	0.2	0.2	0.1	0.3	0.8	8.2	4.1	1.6	1.3	7.1	4.1	6.4	7.0
	13	0.2	0.4	0.3	0.4	0.5	0.3	0.5	1.1	13.7	8.4	2.4	1.6	11.5	5.9	11.6	11.9
14	10	0.1	0.4	0.2	0.2	0.2	0.1	0.4	0.8	11.4	7.0	2.1	1.2	8.8	5.2	9.0	9.6
	13	0.2	0.5	0.3	0.4	0.4	0.3	0.5	1.0	13.6	8.1	2.7	1.8	13.4	6.4	11.4	12.7
16	4	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.4	4.7	2.4	1.4	1.2	5.4	2.8	3.8	4.4
	7	0.2	0.2	0.2	0.3	0.3	0.2	0.4	0.7	9.3	4.5	2.1	1.7	10.6	5.0	7.2	8.3
	13	0.3	0.4	0.3	0.4	0.4	0.3	0.6	1.0	15.0	9.0	2.9	2.1	15.0	6.6	11.6	13.2
	17	0.1	0.3	0.3	0.5	0.3	0.2	0.7	1.3	17.5	8.7	3.4	1.4	19.9	8.4	14.2	15.9
	20	0.1	0.2	0.2	0.4	0.2	0.2	0.6	1.0	17.6	8.9	2.8	1.4	19.7	10.0	11.7	21.7
18	7	0.3	0.3	0.2	0.3	0.3	0.3	0.5	0.7	8.4	3.9	1.9	1.8	9.9	4.4	6.2	8.2
	10	0.3	0.5	0.3	0.4	0.4	0.3	0.6	0.9	12.6	6.7	2.7	2.1	13.3	5.6	9.4	12.1
20	7	0.3	0.3	0.3	0.4	0.4	0.3	0.5	0.7	9.0	3.7	2.3	1.6	9.2	3.7	6.6	8.4
	10	0.4	0.5	0.4	0.5	0.5	0.4	0.6	0.9	13.0	6.0	3.0	1.7	12.6	5.1	9.8	12.3

Table 16

Wave Heights for Plan 17 for Test Waves
from 235 deg

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	5.4	2.9	1.0	0.3	5.2	3.1	4.9	4.1
	10	0.1	0.2	0.2	0.1	0.2	0.1	0.3	0.6	9.6	6.4	1.9	0.5	8.7	4.6	9.9	9.4
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.5	2.5	1.1	0.2	4.4	2.6	4.2	3.8
	7	0.1	0.3	0.1	0.1	0.2	0.1	0.3	0.5	8.0	4.8	1.5	0.4	6.4	3.7	6.9	6.7
	10	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.6	10.0	7.0	1.7	0.7	8.1	4.9	10.2	8.9
	13	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.5	10.9	7.4	2.2	0.8	9.6	4.8	10.3	11.9
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	4.1	2.3	0.8	0.3	3.7	2.7	4.1	3.6
	7	0.1	0.3	0.1	0.1	0.1	0.1	0.2	0.5	10.4	6.5	1.4	0.6	7.5	4.4	8.2	6.4
	13	0.1	0.3	0.2	0.2	0.4	0.2	0.5	1.0	14.0	7.1	2.1	0.8	10.4	6.4	11.7	12.1
14	10	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.7	11.3	6.9	2.5	0.7	9.7	5.5	10.4	9.8
	13	0.2	0.3	0.2	0.3	0.3	0.2	0.4	0.7	12.6	7.0	2.2	0.7	10.5	5.8	12.0	12.8
16	4	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	5.7	2.9	0.8	0.3	6.2	2.9	4.5	3.8
	7	0.1	0.2	0.1	0.1	0.2	0.1	0.3	0.4	10.5	6.3	1.5	0.5	10.3	4.5	8.3	6.8
	13	0.1	0.3	0.2	0.2	0.3	0.2	0.4	0.6	10.8	7.3	2.3	0.7	11.2	6.2	11.8	12.7
	17	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.4	10.9	6.8	3.8	0.8	12.5	4.9	11.3	15.8
	20	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.6	12.8	8.0	3.3	0.9	11.1	7.4	10.8	20.0
18	7	0.1	0.2	0.1	0.2	0.2	0.1	0.3	0.3	9.8	5.0	1.6	0.5	9.7	3.8	6.8	6.4
	10	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.5	12.1	7.9	2.1	0.7	11.6	5.6	9.9	9.6
20	7	0.2	0.3	0.2	0.3	0.2	0.2	0.3	0.4	9.6	7.0	2.0	0.6	10.1	4.7	8.2	7.5
	10	0.2	0.3	0.2	0.3	0.3	0.2	0.4	0.5	11.2	7.9	2.5	0.7	11.0	5.4	10.4	10.3

(Continued)

Table 16 (Concluded)

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	4.2	2.8	0.9	0.5	4.0	2.9	3.9	3.9
	10	0.1	0.4	0.3	0.2	0.2	0.1	0.5	0.9	13.3	8.5	2.3	1.0	11.5	6.3	10.6	10.1
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.6	4.1	2.8	1.5	0.8	3.7	2.9	3.9	4.1
	7	0.1	0.2	0.2	0.2	0.1	0.1	0.4	1.0	9.0	6.6	2.1	1.1	6.9	6.3	7.7	7.4
	10	0.2	0.3	0.3	0.2	0.2	0.2	0.6	1.1	12.2	7.8	2.5	1.3	9.7	7.6	11.1	9.8
	13	0.2	0.5	0.3	0.3	0.3	0.2	0.6	1.1	12.1	10.3	3.3	1.4	11.0	6.4	12.3	12.7
12	4	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.6	4.7	2.6	1.6	0.8	3.4	2.5	3.7	3.5
	7	0.2	0.4	0.2	0.2	0.2	0.1	0.4	1.0	8.7	6.0	2.5	1.2	7.8	5.2	7.9	6.6
	13	0.4	0.6	0.4	0.4	0.5	0.4	0.6	1.1	15.7	10.9	3.3	1.7	13.9	8.3	14.1	12.8
14	10	0.2	0.4	0.2	0.3	0.4	0.2	0.5	0.9	11.6	8.3	3.2	1.5	12.5	6.0	10.6	8.9
	13	0.5	0.6	0.5	0.5	0.6	0.5	0.6	1.2	16.6	10.3	3.6	1.8	14.9	8.5	13.3	12.9
16	4	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.6	6.3	2.8	1.8	1.1	6.1	4.0	4.8	4.1
	7	0.3	0.4	0.2	0.3	0.2	0.2	0.4	0.8	11.2	7.6	2.6	1.4	12.8	6.4	9.0	7.2
	13	0.3	0.4	0.3	0.4	0.5	0.2	0.6	1.1	14.2	10.9	3.8	1.8	15.9	7.6	13.1	11.0
	17	0.1	0.2	0.1	0.3	0.2	0.2	0.4	0.9	18.6	12.4	3.8	0.8	21.9	7.0	15.2	15.7
	20	0.1	0.2	0.1	0.4	0.2	0.2	0.4	0.7	13.7	11.1	4.2	1.1	27.1	8.5	16.3	18.7
18	7	0.3	0.3	0.3	0.4	0.4	0.3	0.5	0.7	12.1	5.6	3.1	1.7	12.6	6.4	7.9	7.0
	10	0.4	0.5	0.3	0.5	0.5	0.3	0.6	0.9	16.1	8.6	4.0	2.0	14.2	8.3	11.0	10.3
20	7	0.4	0.4	0.3	0.4	0.4	0.3	0.5	0.9	12.1	6.4	3.6	1.6	11.8	6.9	9.3	7.4
	10	0.4	0.6	0.3	0.5	0.5	0.3	0.7	1.1	15.5	8.7	3.9	1.7	13.4	8.8	12.1	10.1

Table 17

Wave Heights for Plan 17 for Test Waves
from 210 deg

Test Wave		Wave Height, ft, Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = 0.0 ft																	
8	4	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.3	3.6	4.2	1.1	0.2	3.8	3.2	3.5	3.6
	10	0.1	0.4	0.2	0.2	0.3	0.2	0.5	0.9	8.5	6.5	2.5	0.6	8.7	7.7	9.7	9.9
10	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.2	4.8	1.5	0.3	4.6	3.8	3.7	3.7
	7	0.1	0.3	0.1	0.2	0.1	0.1	0.4	0.8	7.5	6.3	1.7	0.5	7.4	6.8	6.5	6.9
	10	0.1	0.4	0.2	0.2	0.3	0.2	0.5	1.0	10.2	6.7	2.4	0.7	8.7	8.1	10.0	9.9
	13	0.3	0.4	0.3	0.5	0.6	0.4	0.6	1.1	11.8	7.4	4.2	1.1	9.4	9.8	12.0	13.8
12	4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	4.4	5.5	1.9	0.4	3.8	4.0	4.1	4.0
	7	0.1	0.3	0.1	0.2	0.1	0.1	0.3	0.7	7.1	6.6	2.3	0.6	6.5	6.2	6.7	6.7
	13	0.2	0.5	0.3	0.3	0.4	0.2	0.6	1.0	10.4	6.7	3.5	1.1	9.3	8.8	12.7	12.9
14	10	0.2	0.4	0.2	0.3	0.3	0.2	0.5	0.9	10.3	7.1	2.7	0.8	10.7	8.7	10.3	9.9
	13	0.3	0.4	0.3	0.4	0.5	0.4	0.5	0.9	10.2	6.7	3.9	1.0	10.9	8.3	12.7	13.1
16	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	5.1	5.5	1.5	0.5	5.3	3.5	4.1	4.2
	7	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.6	9.7	7.5	2.4	0.7	10.5	6.4	7.2	7.4
	13	0.3	0.4	0.3	0.4	0.5	0.3	0.5	1.0	11.1	8.6	4.4	1.1	12.3	9.8	11.8	13.3
	17	0.1	0.2	0.2	0.2	0.2	0.1	0.5	0.8	14.4	9.3	3.2	1.2	13.3	6.0	12.6	17.8
	20	0.1	0.2	0.2	0.2	0.2	0.2	0.6	1.0	15.1	9.6	4.4	1.1	13.6	9.6	14.3	20.8
18	7	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.5	8.5	7.4	2.7	0.7	8.6	5.4	6.2	6.7
	10	0.3	0.4	0.3	0.4	0.4	0.3	0.5	0.9	12.2	7.9	4.0	1.0	11.1	8.7	9.7	10.3
20	7	0.2	0.3	0.2	0.3	0.3	0.3	0.4	0.6	8.0	7.1	3.2	0.7	9.0	5.6	6.6	6.3
	10	0.3	0.4	0.3	0.4	0.4	0.3	0.5	0.9	10.9	7.6	3.7	1.1	11.0	7.8	10.6	9.3

(Continued)

Table 17 (Concluded)

Test Wave		Wave Height, ft. Gage Number															
Period sec	Height ft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
swl = +5.4 ft																	
8	4	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.6	5.2	4.8	2.0	0.7	5.4	3.8	3.9	4.1
	10	0.2	0.5	0.4	0.3	0.3	0.1	0.5	1.0	11.6	9.6	3.7	1.3	12.0	9.7	10.2	11.0
10	4	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.7	6.0	6.3	2.6	1.1	4.9	5.5	4.9	4.7
	7	0.1	0.3	0.3	0.2	0.2	0.1	0.4	1.1	8.4	10.2	3.7	1.4	8.1	8.9	8.0	7.8
	10	0.2	0.4	0.4	0.3	0.4	0.2	0.5	1.4	13.6	10.3	3.7	1.5	10.7	10.3	10.5	10.7
	13	0.3	0.6	0.5	0.5	0.6	0.4	0.7	1.5	14.4	11.1	4.5	1.9	12.0	10.4	13.4	14.3
12	4	0.1	0.2	0.2	0.1	0.1	0.1	0.3	0.7	4.3	5.1	2.6	0.9	3.8	4.0	4.0	4.2
	7	0.1	0.3	0.3	0.2	0.2	0.1	0.4	1.1	7.8	10.4	4.1	1.3	8.2	7.8	7.7	7.8
	13	0.3	0.6	0.5	0.5	0.6	0.4	0.7	1.6	13.3	11.3	5.1	1.7	14.1	9.9	14.0	12.1
14	10	0.3	0.4	0.4	0.4	0.4	0.3	0.5	1.2	10.7	10.1	4.0	1.6	12.0	10.1	10.0	10.1
	13	0.4	0.6	0.5	0.6	0.7	0.4	0.7	1.6	16.1	12.5	4.7	1.9	16.2	12.2	13.6	14.2
16	4	0.1	0.2	0.2	0.2	0.2	0.1	0.3	0.6	6.4	5.7	2.7	1.1	5.7	4.2	4.2	4.7
	7	0.3	0.3	0.3	0.4	0.3	0.3	0.4	0.9	10.0	9.3	4.1	1.7	11.1	7.0	7.5	7.6
	13	0.3	0.4	0.4	0.5	0.4	0.4	0.7	1.2	11.8	11.3	5.4	2.1	17.0	11.7	13.4	13.5
	17	0.1	0.3	0.3	0.5	0.3	0.2	0.6	1.0	19.1	13.6	8.9	4.2	15.5	10.2	13.3	20.0
	20	0.1	0.3	0.3	0.5	0.3	0.2	0.6	0.9	16.7	14.3	8.0	2.9	18.7	10.8	14.4	22.0
18	7	0.3	0.4	0.4	0.5	0.4	0.4	0.5	0.7	9.2	8.3	4.2	1.7	9.5	6.2	6.2	7.5
	10	0.4	0.5	0.4	0.5	0.6	0.4	0.6	1.0	12.7	10.5	5.5	2.0	12.6	9.6	9.6	11.0
20	7	0.4	0.4	0.4	0.4	0.5	0.4	0.5	1.0	8.3	8.6	5.0	1.8	10.0	6.6	8.3	6.9
	10	0.4	0.6	0.5	0.6	0.6	0.5	0.7	1.2	12.6	10.5	5.8	1.9	12.6	8.2	10.7	9.9



Photo 1. Typical wave patterns for existing conditions
(with shoaled entrance), 10-sec, 4-ft waves from
250 deg, swl = +5.4 ft

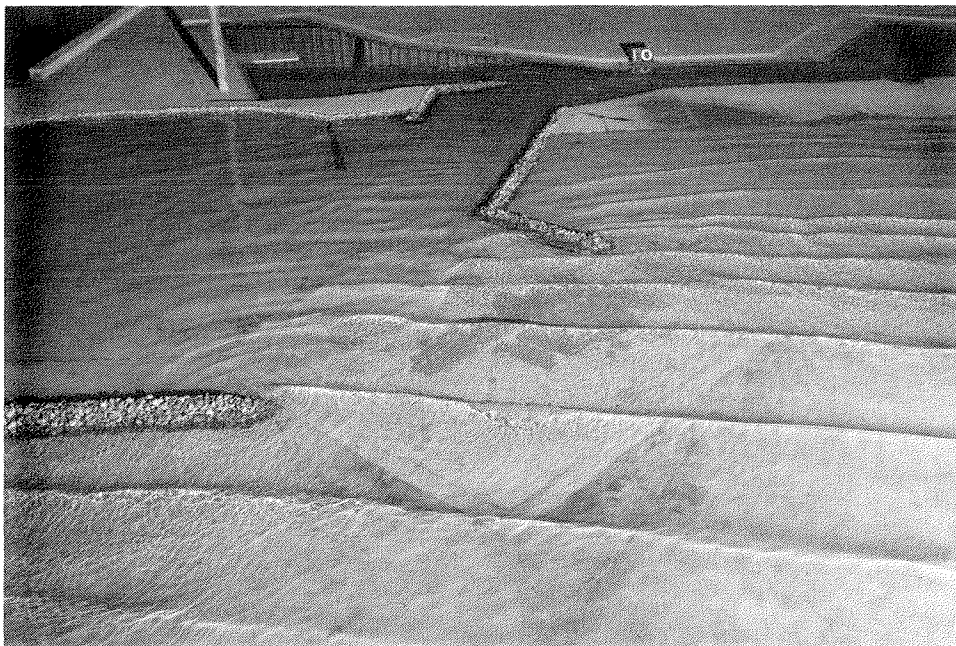


Photo 2. Typical wave patterns for existing conditions
(with shoaled entrance), 14-sec, 10-ft waves from
250 deg, swl = +5.4 ft



Photo 3. Typical wave patterns for existing conditions
(with shoaled entrance), 16-sec, 13-ft waves from
250 deg, swl = +5.4 ft



Photo 4. Typical wave patterns for existing conditions
(with shoaled entrance), 10-sec, 4-ft waves from
235 deg, swl = +5.4 ft



Photo 5. Typical wave patterns for existing conditions
(with shoaled entrance), 14-sec, 10-ft waves from
235 deg, swl = +5.4 ft



Photo 6. Typical wave patterns for existing conditions
(with shoaled entrance), 16-sec, 13-ft waves from
235 deg, swl = +5.4 ft



Photo 7. Typical wave patterns for existing conditions
(with shoaled entrance), 10-sec, 4-ft waves from
210 deg, swl = +5.4 ft



Photo 8. Typical wave patterns for existing conditions
(with shoaled entrance), 14-sec, 10-ft waves from
210 deg, swl = +5.4 ft



Photo 9. Typical wave patterns for existing conditions
(with shoaled entrance), 16-sec, 13-ft waves from
210 deg, swl = +5.4 ft



Photo 10. General movement of tracer material and
subsequent deposits for existing conditions for
14-sec, 10-ft waves from 250 deg, swl = 0.0 ft

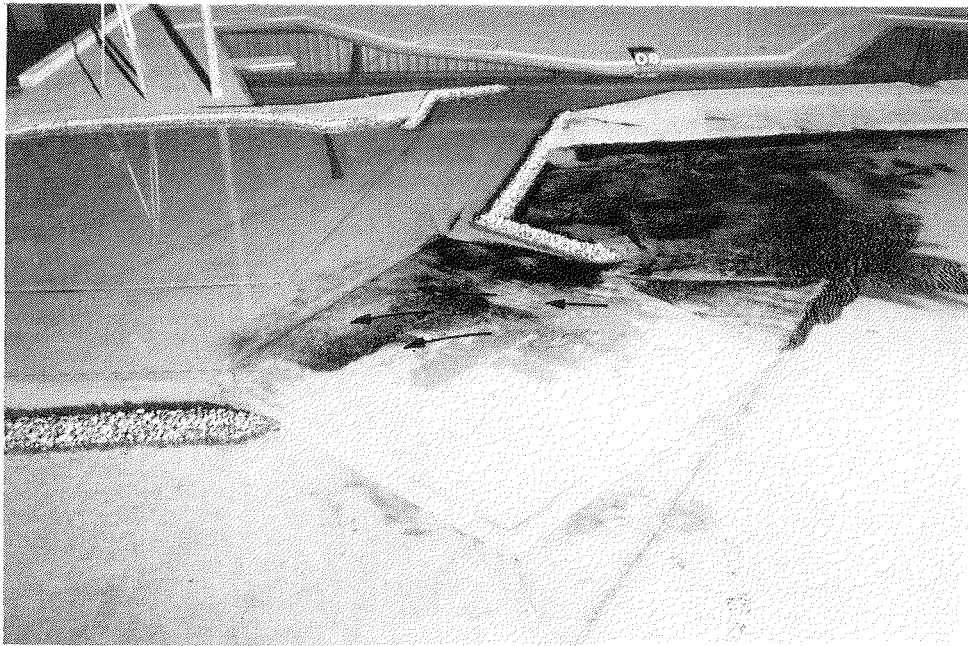


Photo 11. General movement of tracer material and subsequent deposits for existing conditions for 14-sec, 10-ft waves from 195 deg, swl = 0.0 ft



Photo 12. Typical wave patterns for existing conditions (with authorized entrance channel depths), 10-sec, 4-ft waves from 235 deg, swl = +5.4 ft



Photo 13. Typical wave patterns for existing conditions
(with authorized entrance channel depths), 14-sec,
10-ft waves from 235 deg, swl = +5.4 ft



Photo 14. Typical wave patterns for existing conditions
(with authorized entrance channel depths), 16-sec,
13-ft waves from 235 deg, swl = +5.4 ft



Photo 15. Typical wave patterns for Plan 1; 10-sec,
4-ft waves from 235 deg, swl = +5.4 ft

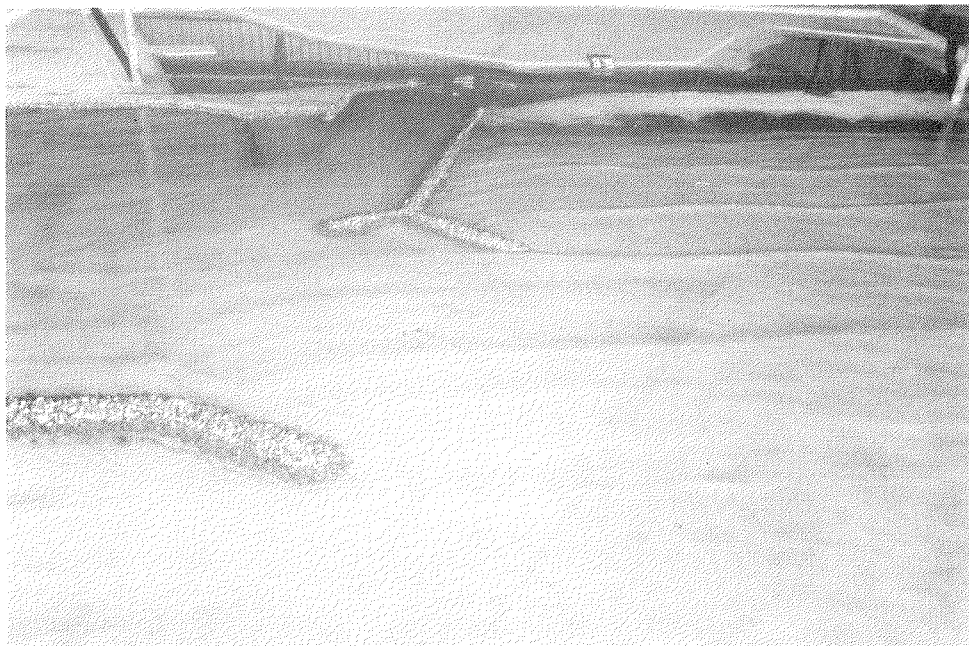


Photo 16. Typical wave patterns for Plan 1; 14-sec,
10-ft waves from 235 deg, swl = +5.4 ft

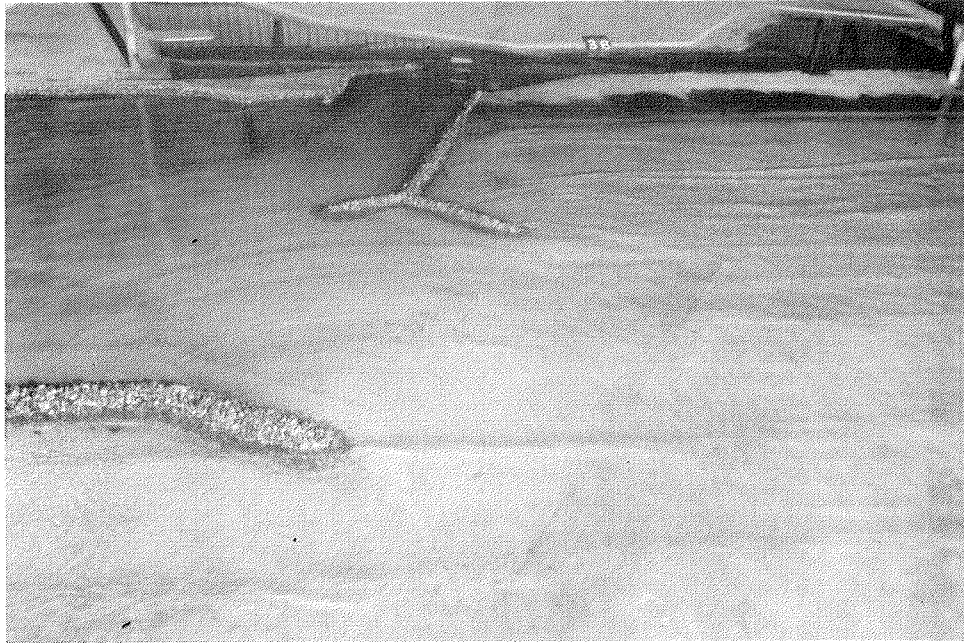


Photo 17. Typical wave patterns for Plan 1; 16-sec,
13-ft waves from 235 deg, swl = +5.4 ft

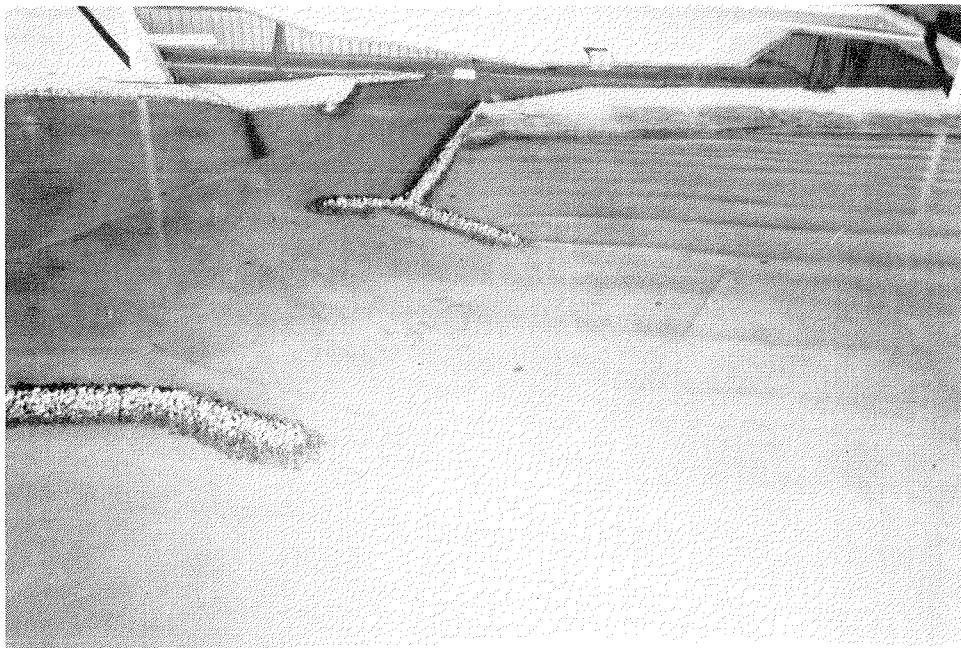


Photo 18. Typical wave patterns for Plan 17; 10-sec,
4-ft waves from 250 deg, swl = +5.4 ft



Photo 19. Typical wave patterns for Plan 17; 14-sec,
10-ft waves from 250 deg, swl = +5.4 ft

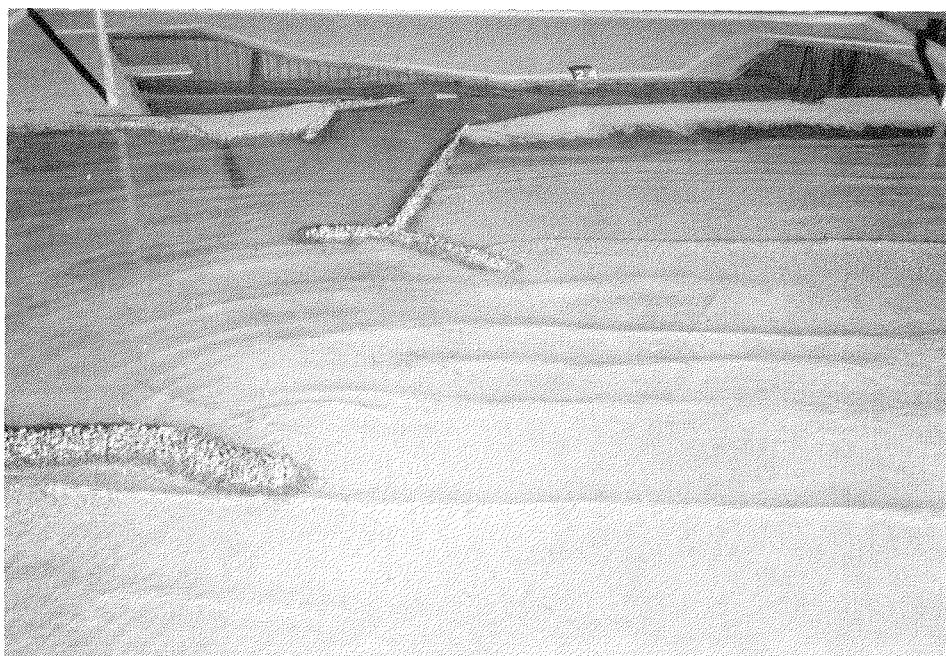


Photo 20. Typical wave patterns for Plan 17; 10-sec,
13-ft waves from 250 deg, swl = +5.4 ft

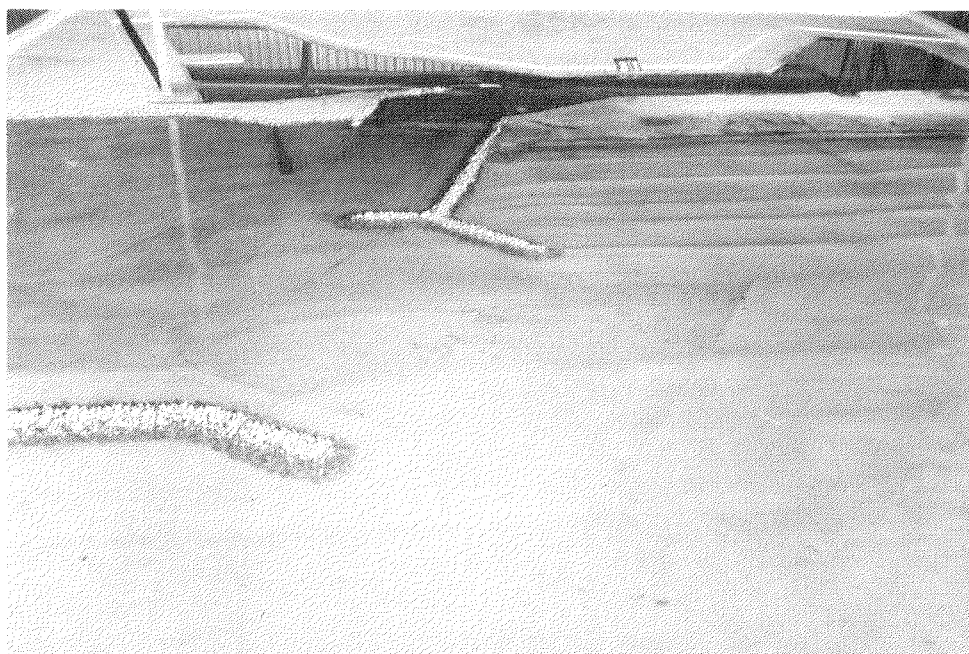


Photo 21. Typical wave patterns for Plan 17; 10-sec,
4-ft waves from 235 deg, swl = +5.4 ft

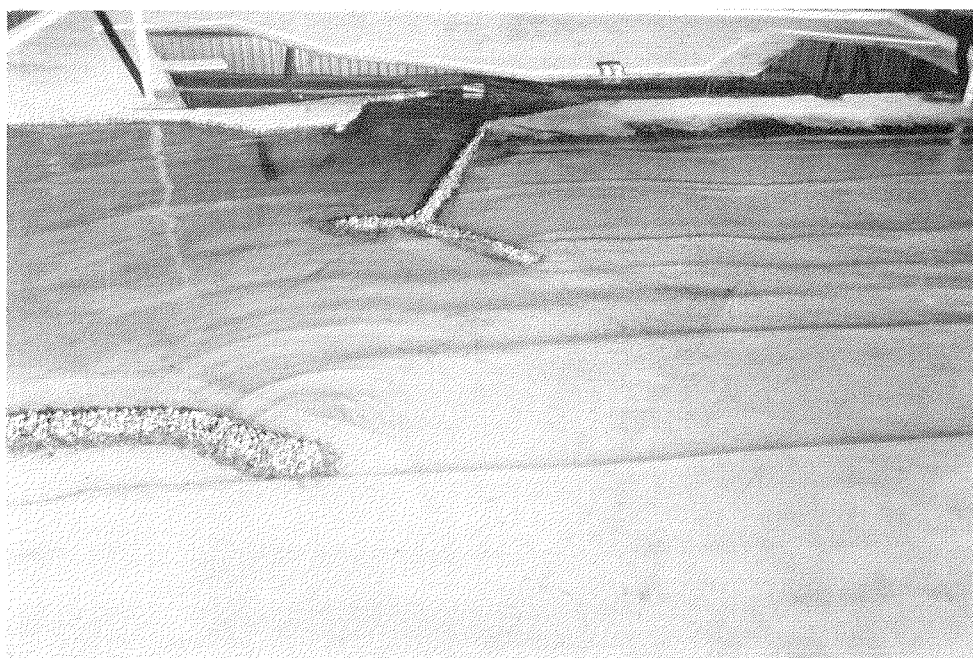


Photo 22. Typical wave patterns for Plan 17; 14-sec,
10-ft waves from 235 deg, swl = +5.4 ft

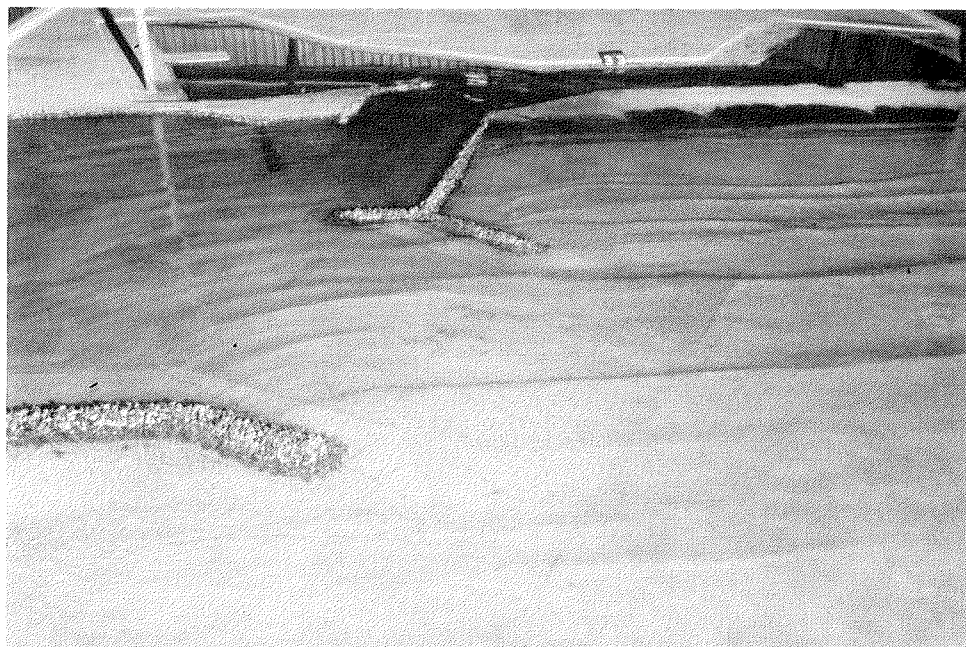


Photo 23. Typical wave patterns for Plan 17; 16-sec,
13-ft waves from 235 deg, swl = +5.4 ft



Photo 24. Typical wave patterns for Plan 17; 10-sec,
4-ft waves from 210 deg, swl = +5.4 ft



Photo 25. Typical wave patterns for Plan 17; 14-sec,
10-ft waves from 210 deg, swl = +5.4 ft



Photo 26. Typical wave patterns for Plan 17; 16-sec,
13-ft waves from 210 deg, swl = +5.4 ft



Photo 27. General movement of tracer material and subsequent deposits for Plan 17 for 14-sec, 10-ft waves from 250 deg, swl = 0.0 ft

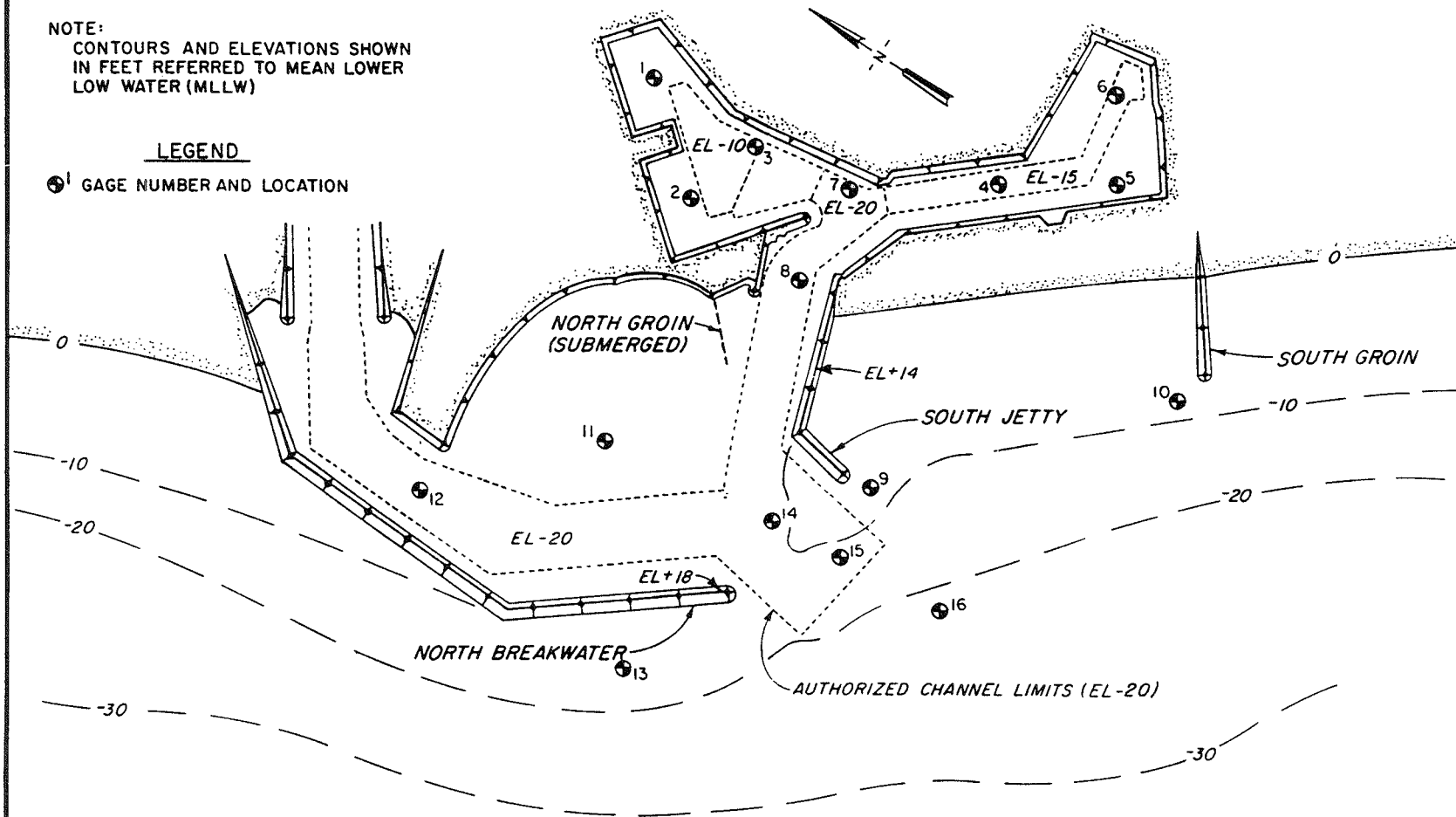


Photo 28. General movement of tracer material and subsequent deposits for Plan 17 for 14-sec, 10-ft waves from 195 deg, swl = 0.0 ft

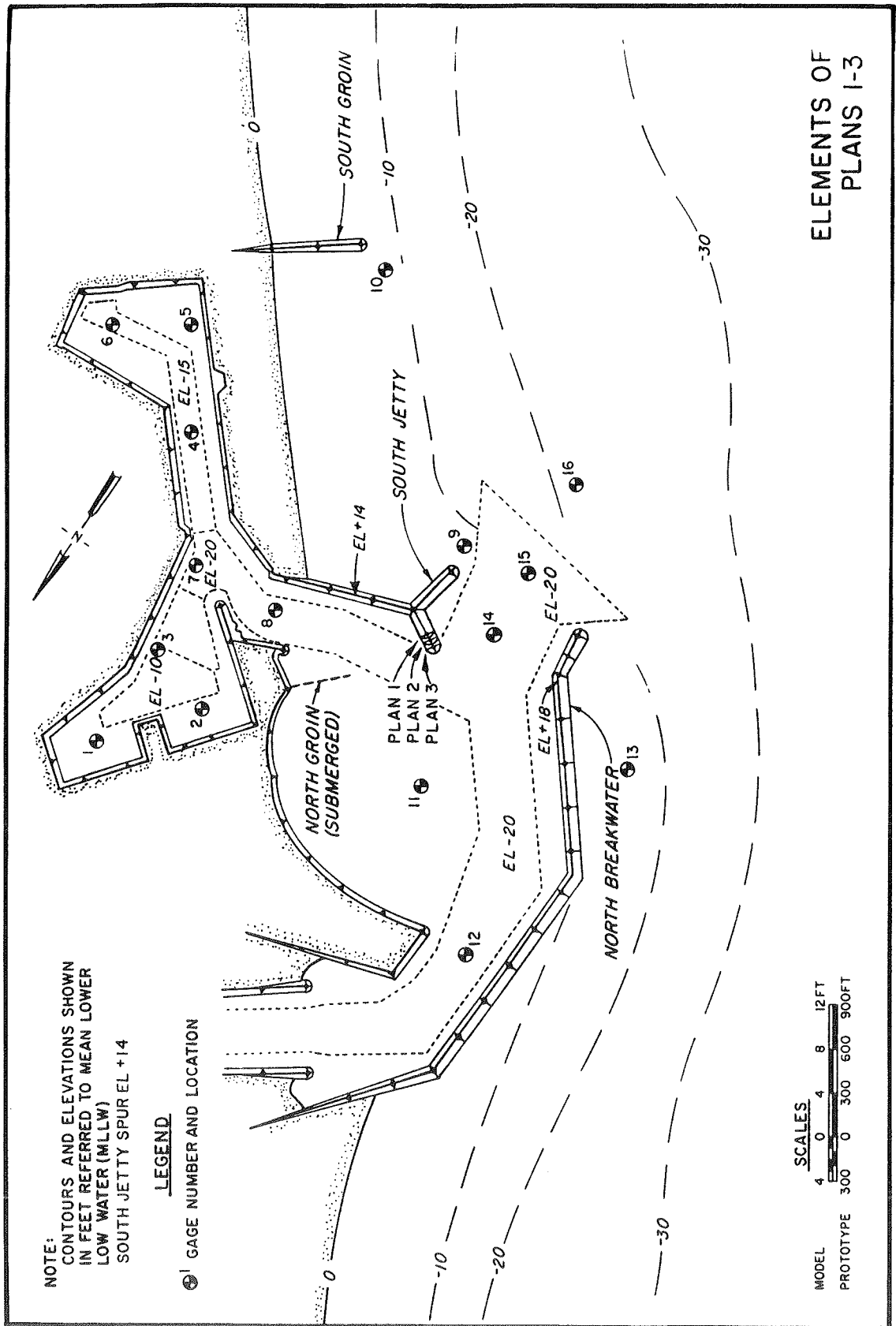
NOTE:
CONTOURS AND ELEVATIONS SHOWN
IN FEET REFERRED TO MEAN LOWER
LOW WATER (MLLW)

LEGEND

① GAGE NUMBER AND LOCATION



EXISTING CONDITIONS

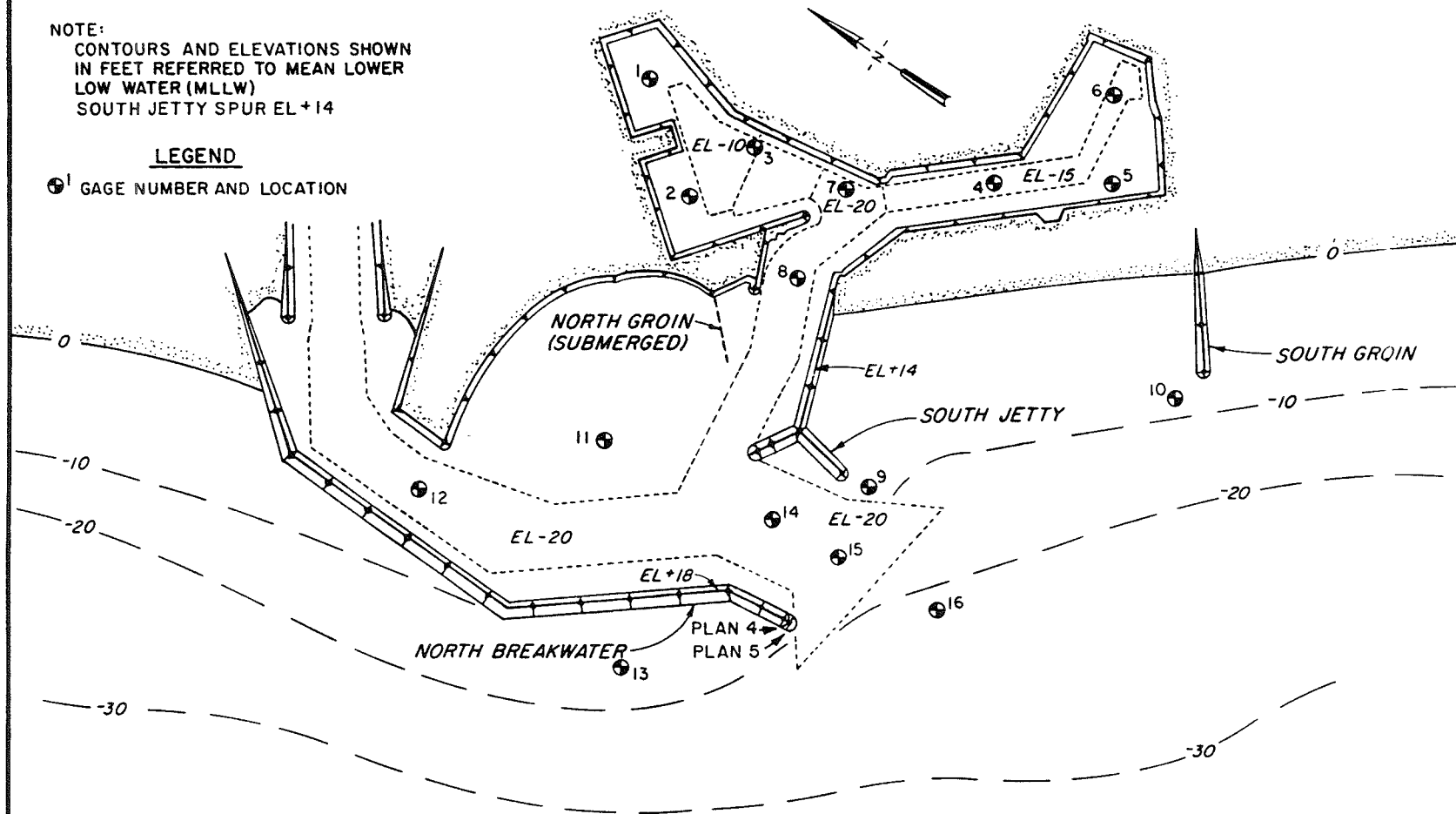


ELEMENTS OF PLANS 1-3

NOTE:
 CONTOURS AND ELEVATIONS SHOWN
 IN FEET REFERRED TO MEAN LOWER
 LOW WATER (MLLW)
 SOUTH JETTY SPUR EL +14

LEGEND

① GAGE NUMBER AND LOCATION



SCALES

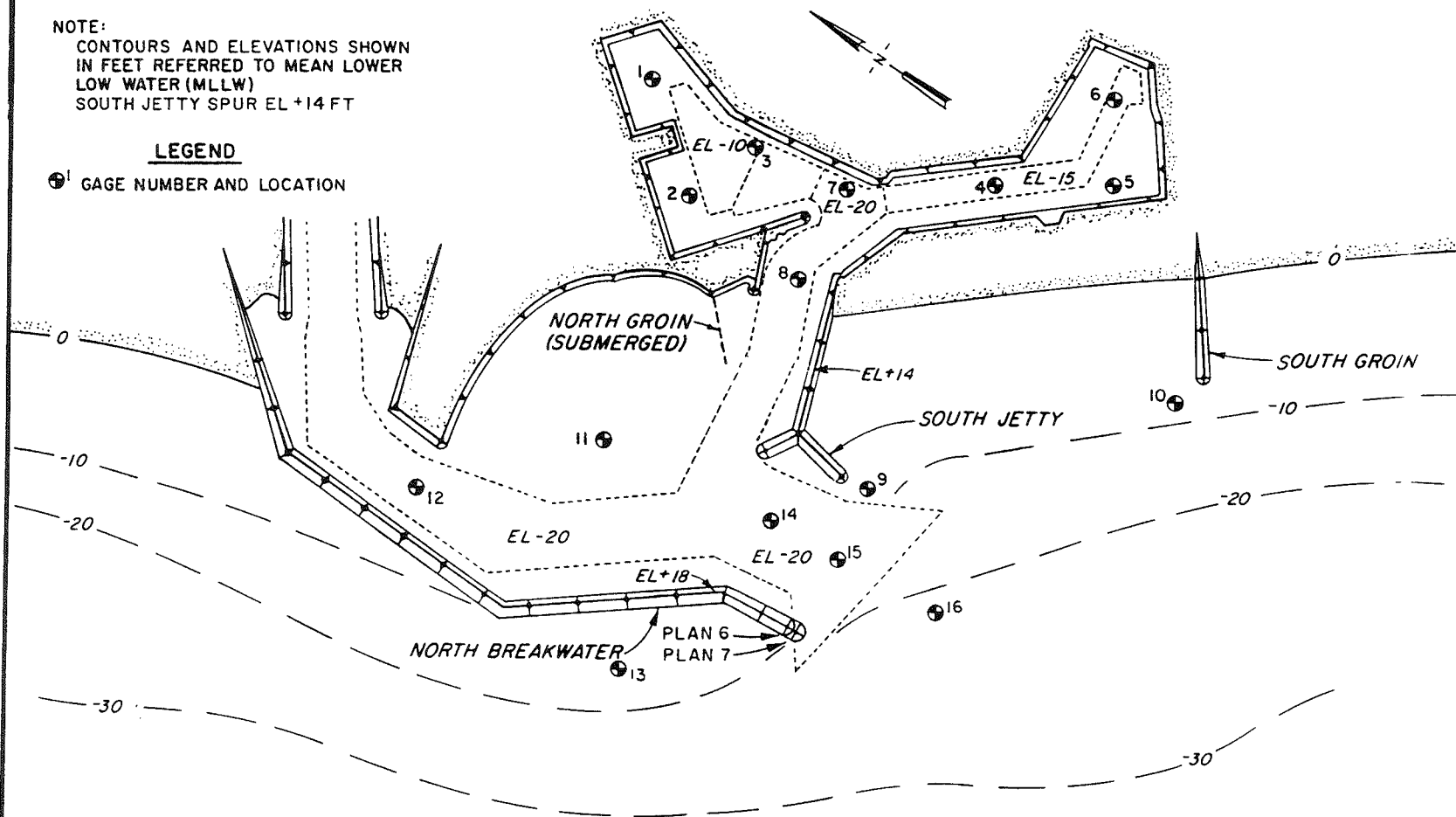
MODEL	4	0	4	8	12 FT
PROTOTYPE	300	0	300	600	900 FT

ELEMENTS OF
 PLANS 4 AND 5

NOTE:
CONTOURS AND ELEVATIONS SHOWN
IN FEET REFERRED TO MEAN LOWER
LOW WATER (MLLW)
SOUTH JETTY SPUR EL +14 FT

LEGEND

⊕¹ GAGE NUMBER AND LOCATION



SCALES

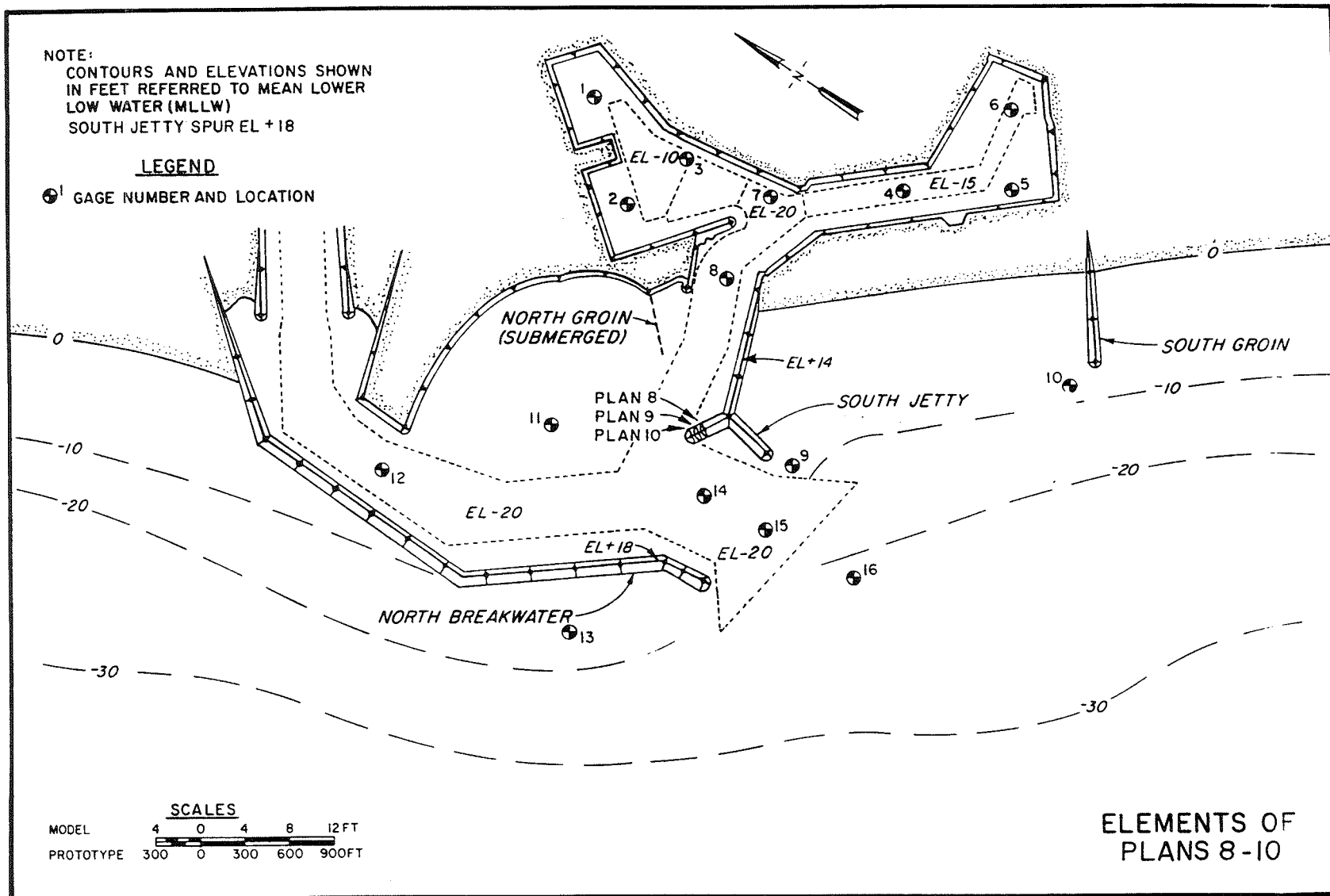
MODEL	4	0	4	8	12 FT
PROTOTYPE	300	0	300	600	900 FT

ELEMENTS OF
PLANS 6 AND 7

NOTE:
CONTOURS AND ELEVATIONS SHOWN
IN FEET REFERRED TO MEAN LOWER
LOW WATER (MLLW)
SOUTH JETTY SPUR EL +18

LEGEND

⊕¹ GAGE NUMBER AND LOCATION

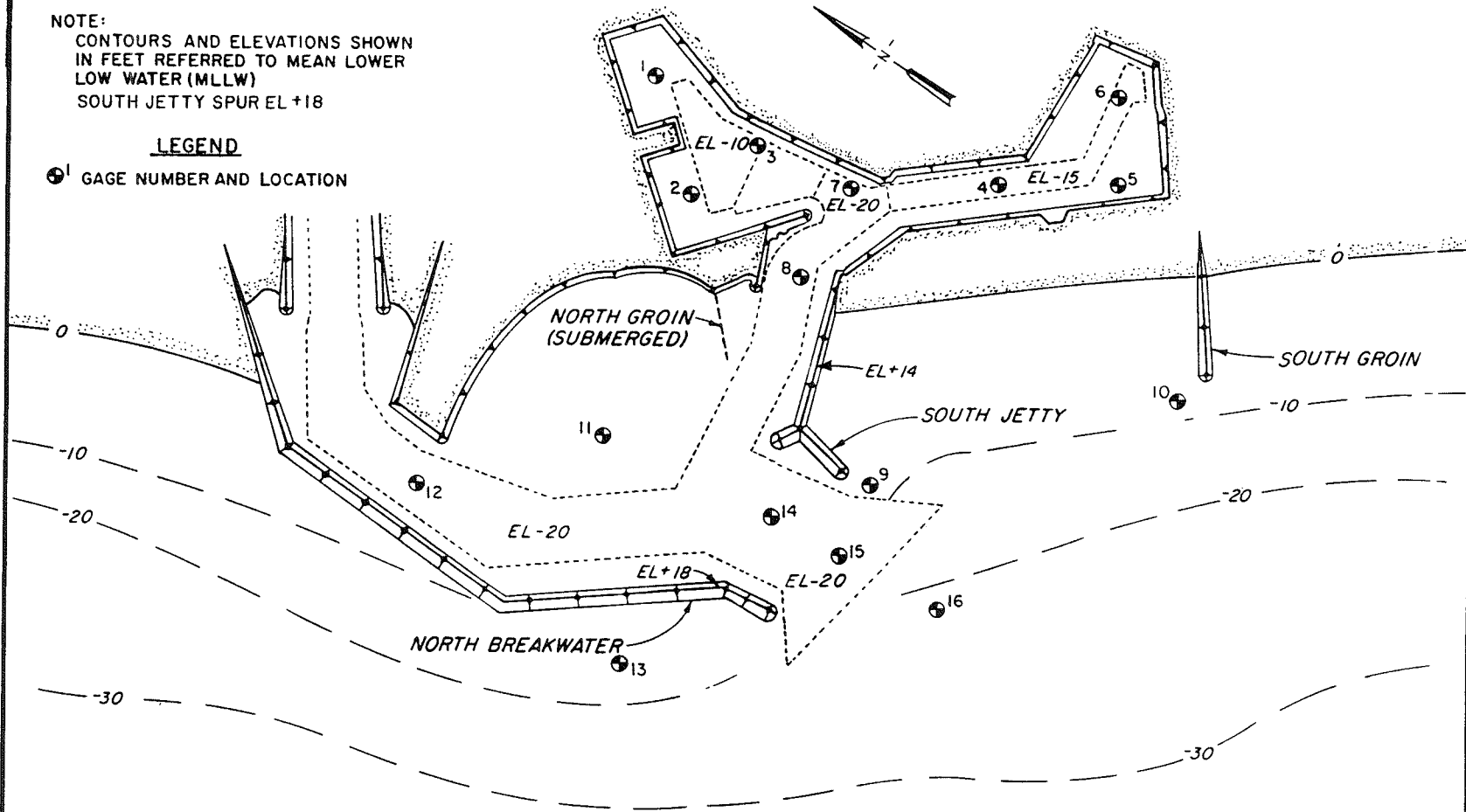


ELEMENTS OF
PLANS 8-10

NOTE:
CONTOURS AND ELEVATIONS SHOWN
IN FEET REFERRED TO MEAN LOWER
LOW WATER (MLLW)
SOUTH JETTY SPUR EL+18

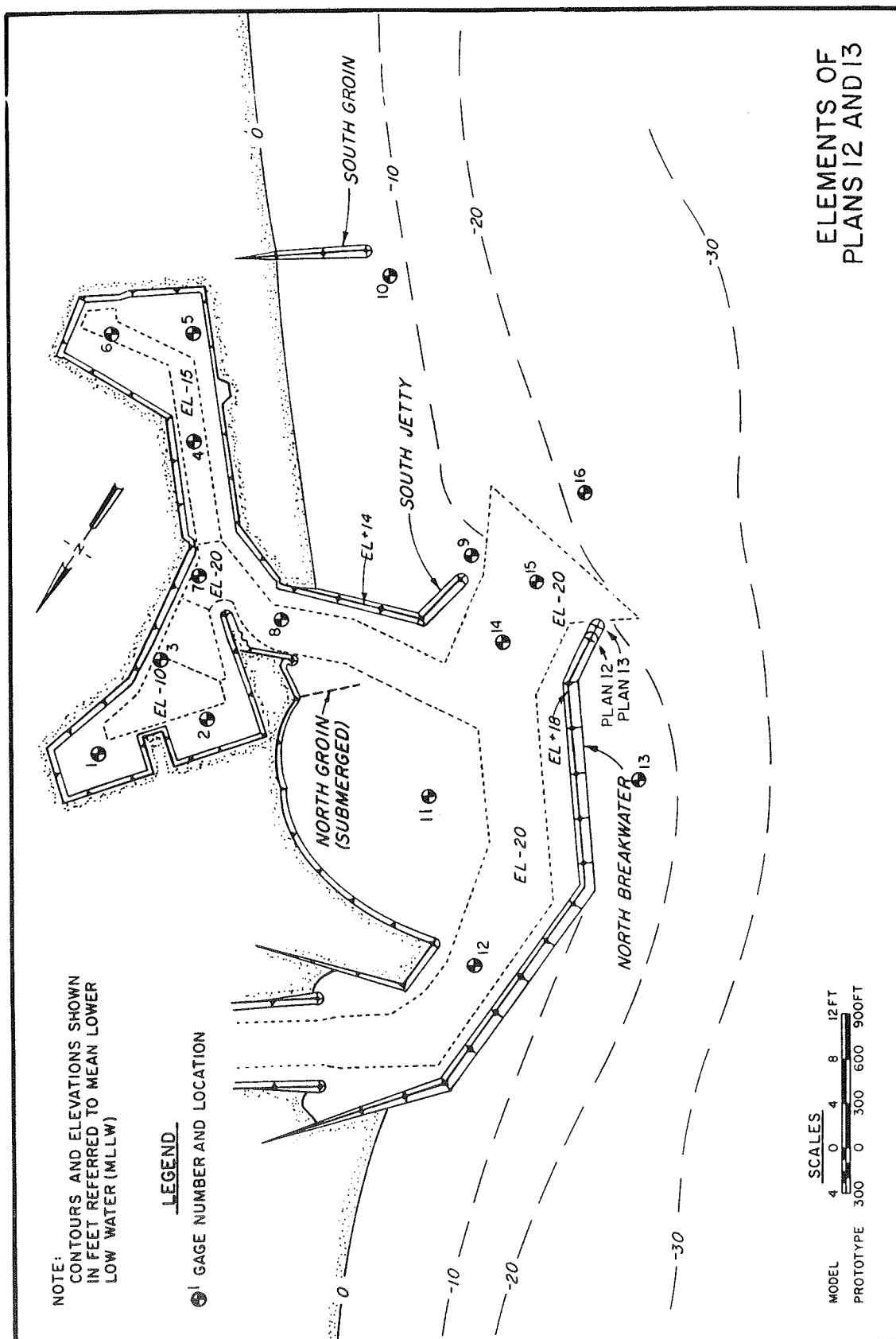
LEGEND

⊙¹ GAGE NUMBER AND LOCATION



SCALES
MODEL 4 0 4 8 12 FT
PROTOTYPE 300 0 300 600 900 FT

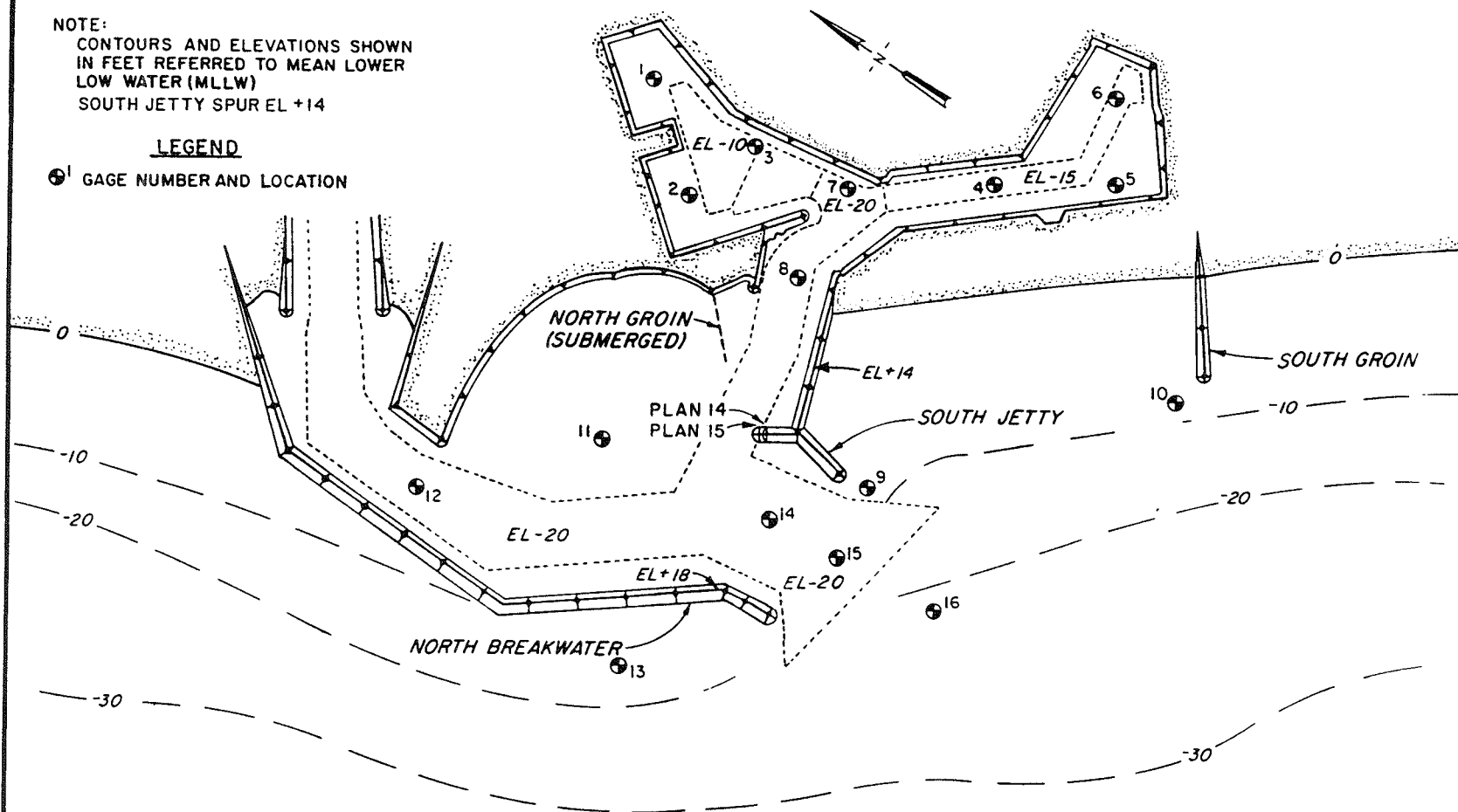
ELEMENTS OF
PLAN II



NOTE:
 CONTOURS AND ELEVATIONS SHOWN
 IN FEET REFERRED TO MEAN LOWER
 LOW WATER (MLLW)
 SOUTH JETTY SPUR EL +14

LEGEND

⊙¹ GAGE NUMBER AND LOCATION



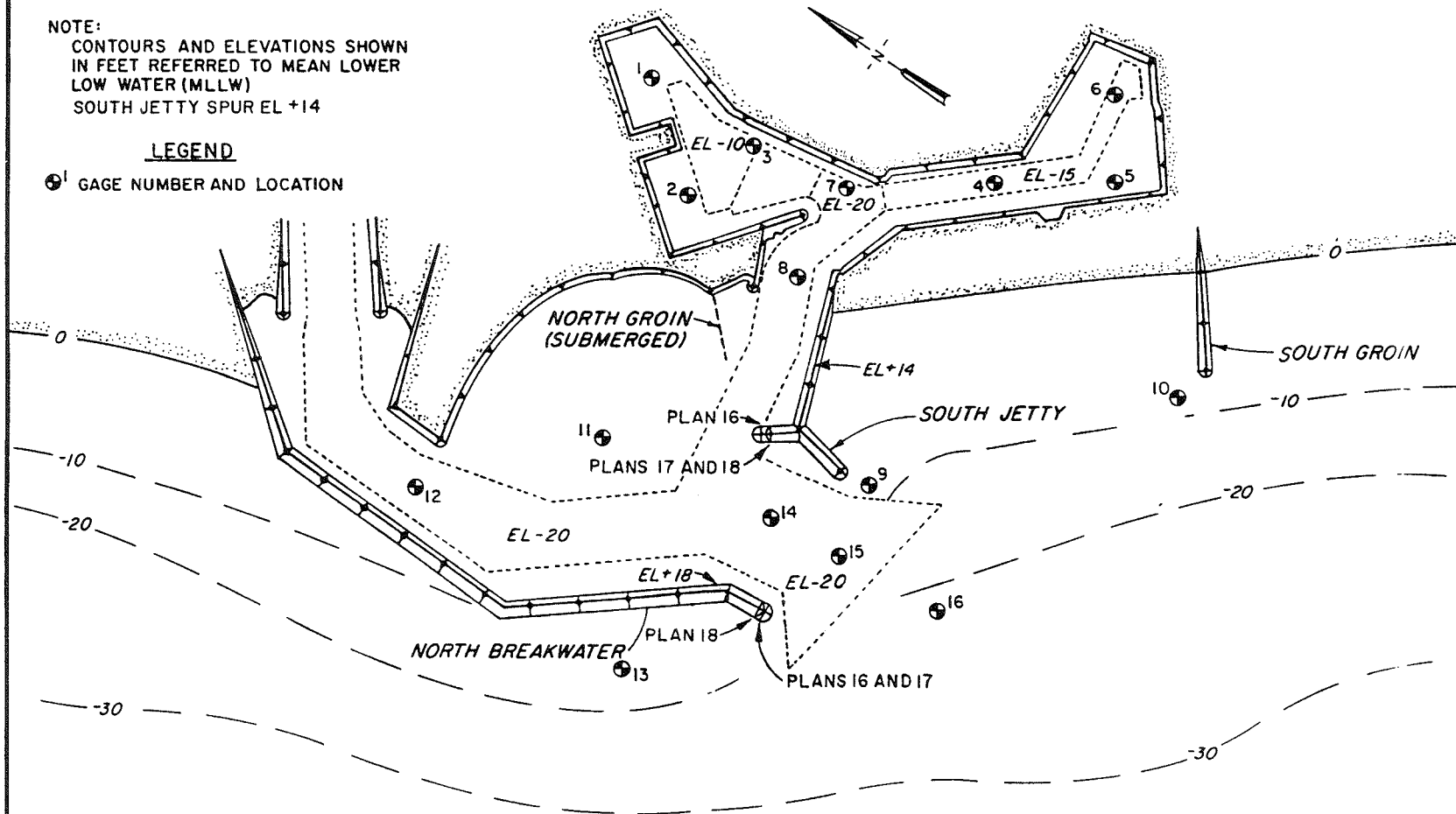
SCALES
 MODEL 4 0 4 8 12 FT
 PROTOTYPE 300 0 300 600 900 FT

ELEMENTS OF
 PLANS 14 AND 15

NOTE:
 CONTOURS AND ELEVATIONS SHOWN
 IN FEET REFERRED TO MEAN LOWER
 LOW WATER (MLLW)
 SOUTH JETTY SPUR EL +14

LEGEND

⊙¹ GAGE NUMBER AND LOCATION



ELEMENTS OF
 PLANS 16-18

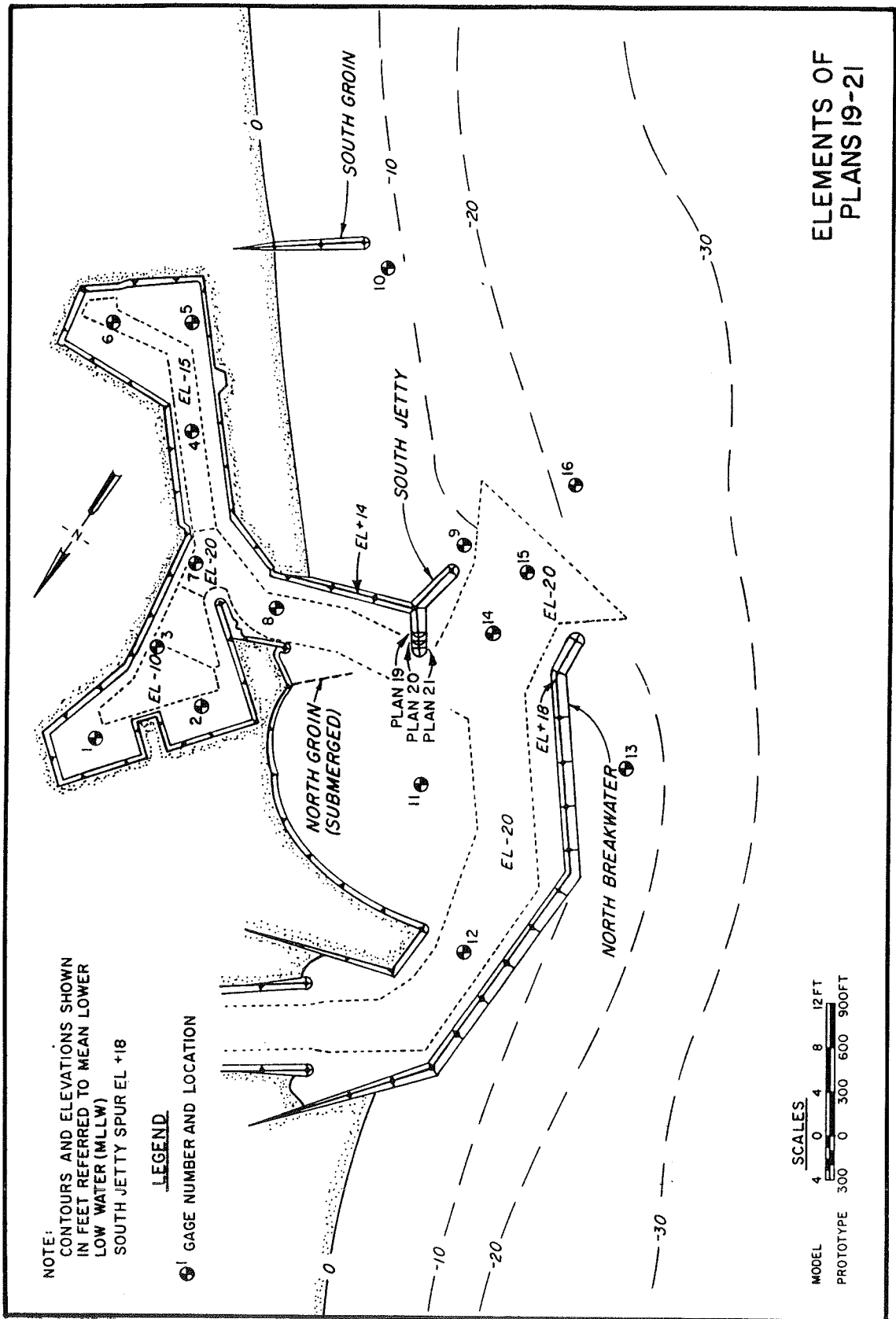
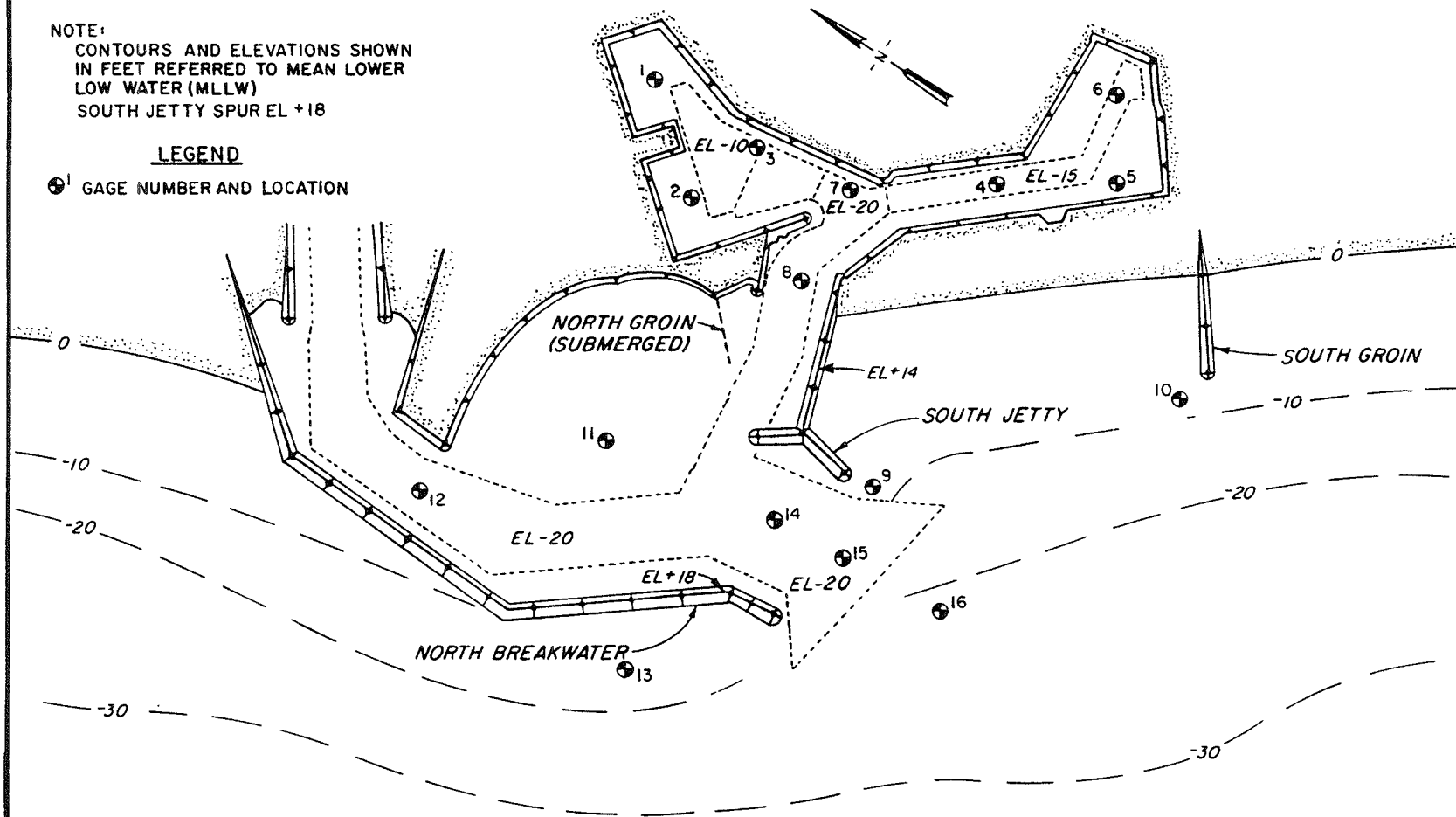


PLATE 10

NOTE:
 CONTOURS AND ELEVATIONS SHOWN
 IN FEET REFERRED TO MEAN LOWER
 LOW WATER (MLLW)
 SOUTH JETTY SPUR EL +18

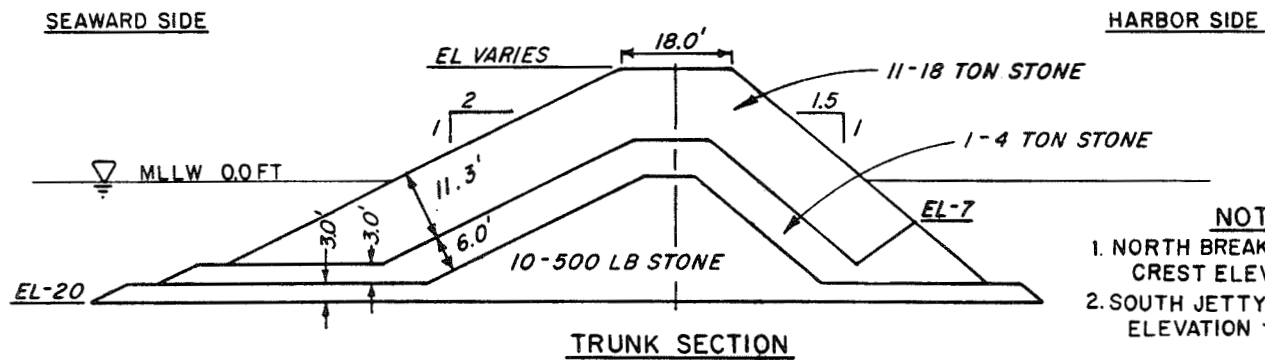
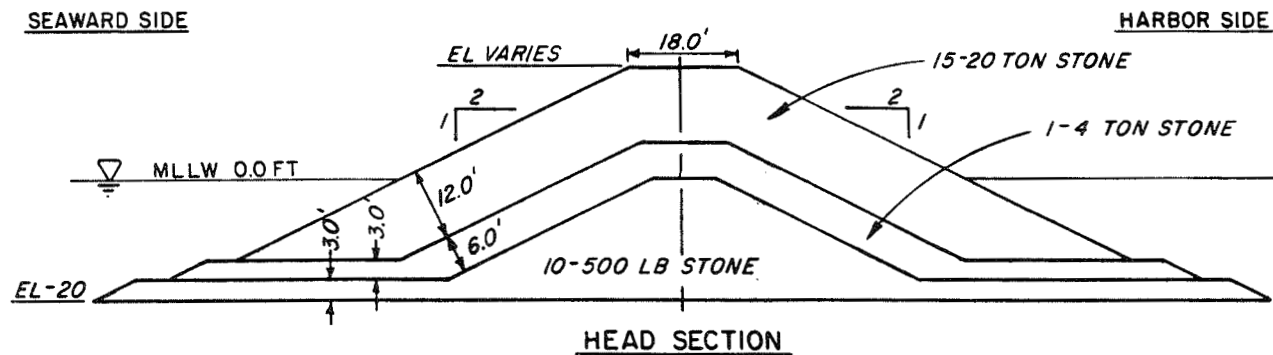
LEGEND

⊕¹ GAGE NUMBER AND LOCATION

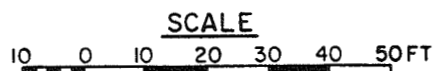


SCALES
 MODEL 4 0 4 8 12 FT
 PROTOTYPE 300 0 300 600 900 FT

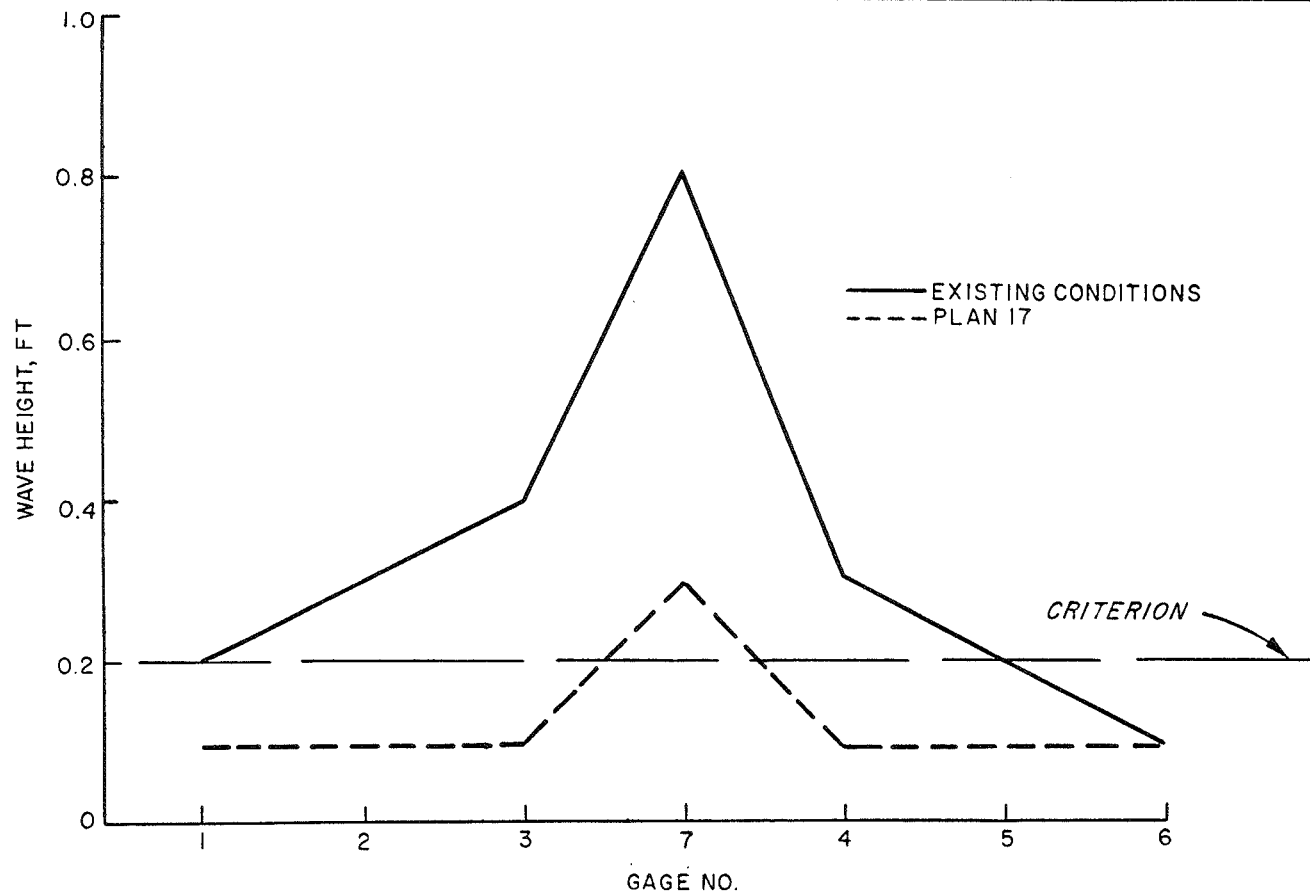
ELEMENTS OF
 PLAN 22



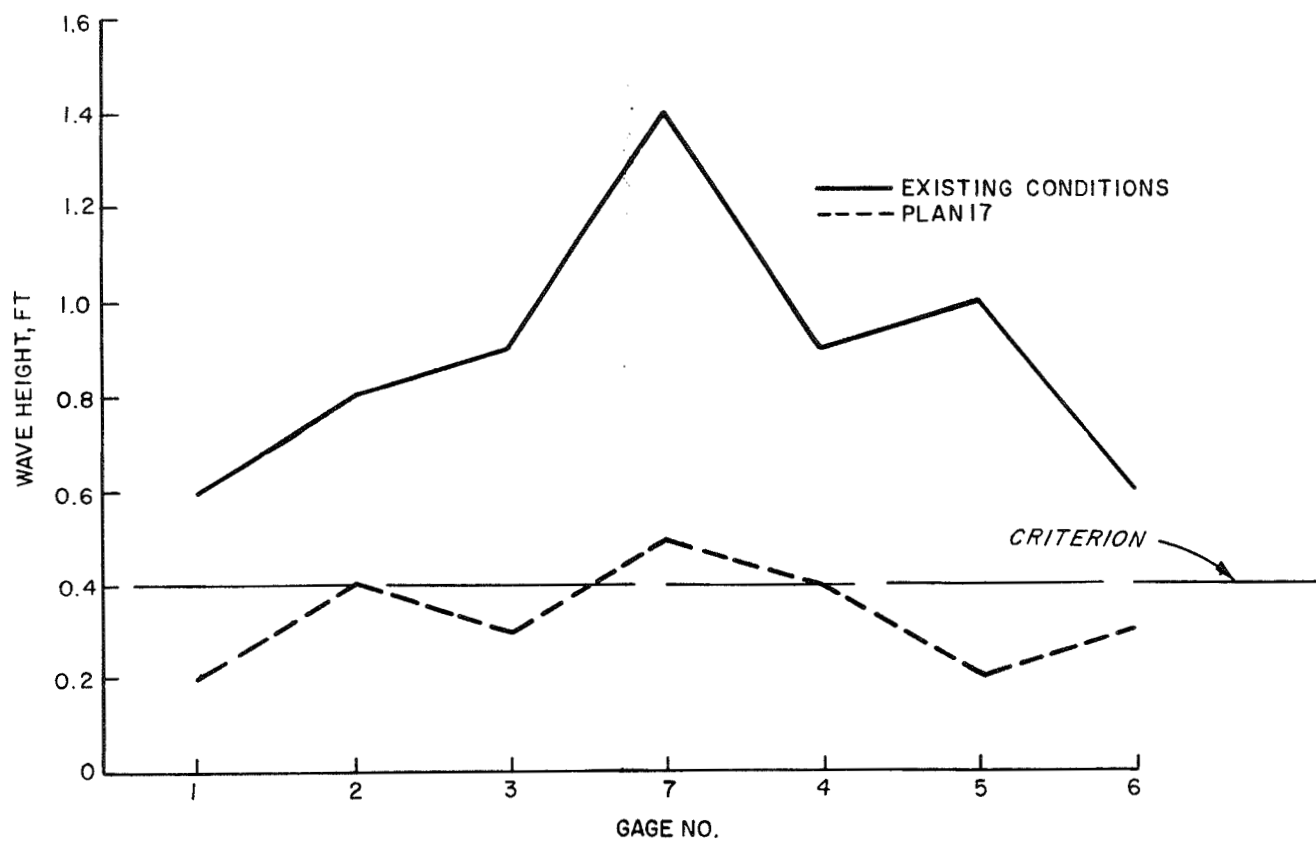
- NOTES
1. NORTH BREAKWATER EXTENSION
CREST ELEVATION +18 FT
 2. SOUTH JETTY SPUR CREST
ELEVATION +14 FT OR +18 FT



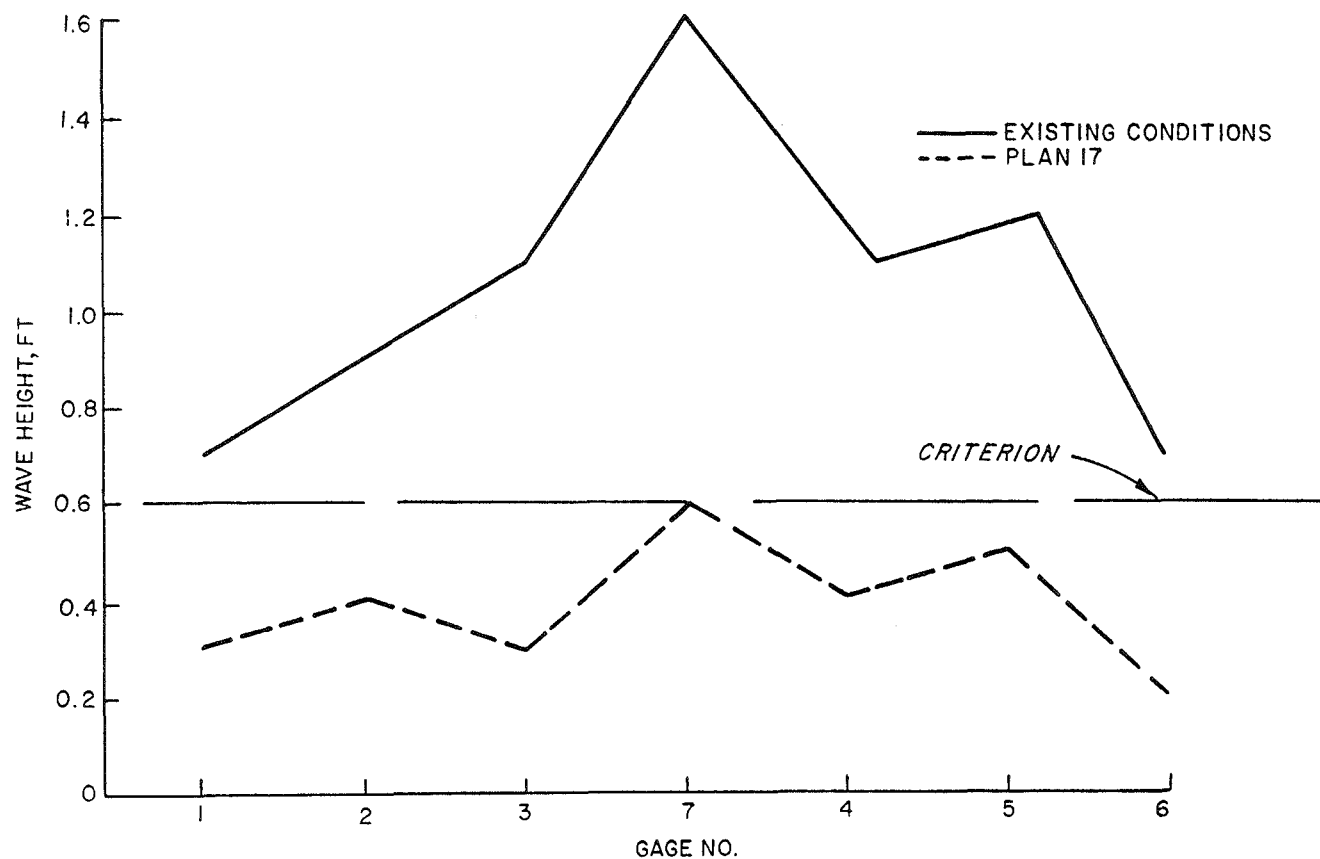
TYPICAL NORTH BREAKWATER EXTENSION
AND SOUTH JETTY SPUR SECTION



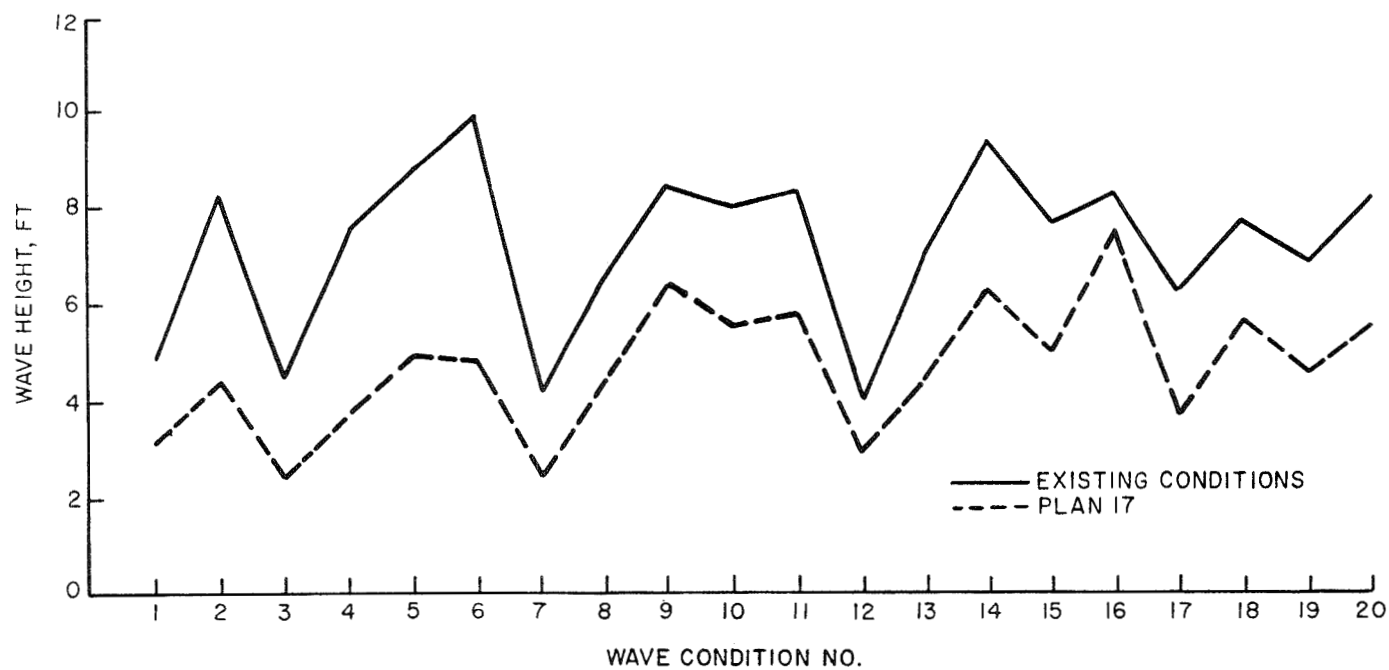
COMPARISON OF MAXIMUM WAVE HEIGHTS
IN INNER BASINS FOR EXISTING CONDITIONS
AND PLAN 17
WEEKLY WAVE CONDITIONS FROM 235 DEG
SWL = +5.4 FT



COMPARISON OF MAXIMUM WAVE HEIGHTS
IN INNER BASINS FOR EXISTING CONDITIONS
AND PLAN 17
ANNUAL WAVE CONDITIONS FROM 235 DEG
SWL = +5.4 FT



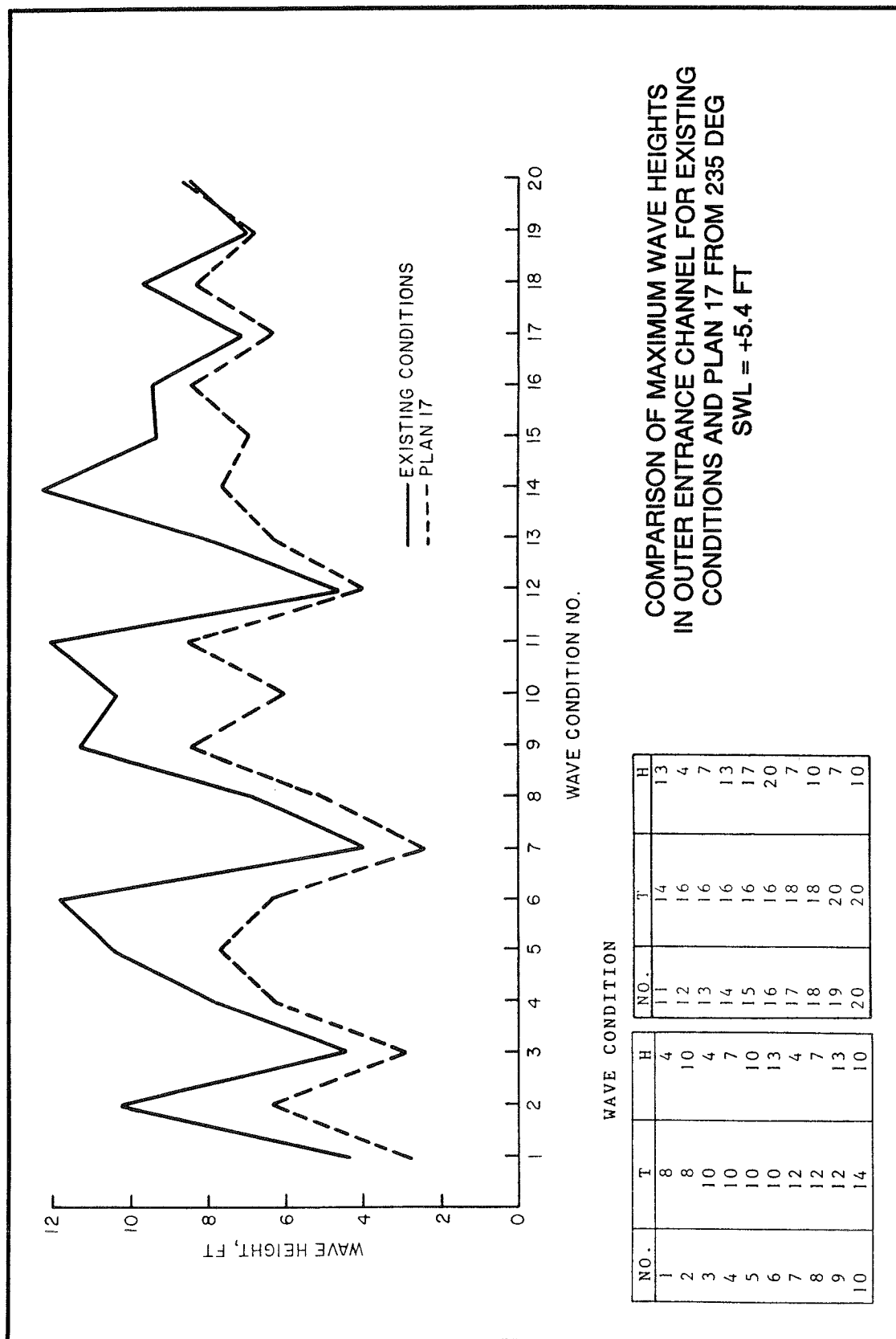
COMPARISON OF MAXIMUM WAVE HEIGHTS
IN INNER BASINS FOR EXISTING CONDITIONS
AND PLAN 17
20-YR WAVE CONDITIONS FROM 235 DEG
SWL = +5.4 FT



WAVE CONDITION

NO.	T	H	NO.	T	H
1	8	4	11	14	13
2	8	10	12	16	4
3	10	4	13	16	7
4	10	7	14	16	13
5	10	10	15	16	17
6	10	13	16	16	20
7	12	4	17	18	7
8	12	7	18	18	10
9	12	13	19	20	7
10	14	10	20	20	10

COMPARISON OF MAXIMUM WAVE HEIGHTS
IN OUTER ENTRANCE CHANNEL FOR EXISTING
CONDITIONS AND PLAN 17 FROM 235 DEG
SWL = 0.0 FT



Waterways Experiment Station Cataloging-in-Publication Data

Bottin, Robert R.

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Includes bibliographical references.

1. Harbors — California — Oceanside — Design and construction.
2. Harbors — California — Oceanside — Hydrodynamics — Models.
3. Breakwaters — California — Oceanside — Design and construction.
4. Hydraulic models. I. United States. Army. Corps of Engineers. Los Angeles District. II. Coastal Engineering Research Center (U.S.) III. U.S. Army Engineer Waterways Experiment Station. IV. Title. V. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; CERC-92-14.

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